# MYCOTAXON

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VOLUME 130(2) APRIL–JUNE 2015

***Mycorrhaphium pusillum*** (redescribed)
**(Tervonen, Spirin, & Halme— FIG. 3, p. 553)**
**VIACHESLAV SPIRIN *artist***

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# MYCOTAXON

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## Reviewers — volume one hundred thirty (two)

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N.S. Afshan
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## Errata from previous volumes

### Volume 123

| | | |
|---|---|---|
| p. 479, line 2 | for: Nguyen Anh Dzung | read: Anh Dzung Nguyen |

### Volume 124

| | | |
|---|---|---|
| p. 51, lines 2–3 | for: Nguyen Anh Dzung | read: Anh Dzung Nguyen |
| p. 309, line 2 | for: Nguyen Anh Dzung | read: Anh Dzung Nguyen |

### Volume 125

| | | |
|---|---|---|
| p. 69, line 3 | for: Nguyen Anh Dzung | read: Anh Dzung Nguyen |

### Volume 130(1)

| | | |
|---|---|---|
| p. 22, line 11 | for: Q = 1.29–1.39 | read: Q = 1.33 |
| p. 61, line 9 | for: School of Life Science | read: College of Life Science |
| p. 61, line 13 | for: Academia of Agriculture | read: Academy of Agriculture |

publication date for volume one hundred thirty (one)
MYCOTAXON *for* January–March, (i–vi + 1–306)
*was issued on April 22, 2015*

# From the Editor-in-Chief

Mycotaxon 130(2) contains 32 research papers by 112 authors (representing 18 countries) and reviewed by 50 expert reviewers. Within its pages are four new genera (*Anaexserticlava, Brachycephala, Distophragmia,* and *Phaeoschizotrichum*) and 26 species new to science representing *Allocetraria, Aspicilia, Endophragmiella, Graphis, Leptogium, Melanoderma, Micropsalliota, Neosporidesmium,* & *Rosellinia* from China; *Anaexserticlava, Brachycephala, Cryptocoryneum, Chaetochalara, Digicatenosporium, Diplococcium, Distophragmia, Matsushimiella, Phaeoschizotrichum,* & *Pyriculariopsis* from Brazil; *Duportella* from Northeast Asia; *Graphilbum* from Canada; *Leucoagaricus* from Pakistan; and *Spadicoides* & *Sporidesmiella* from Mexico.

In addition to range extensions (in Brazil, Niger, Pakistan, Thailand, & Vietnam) and/or new hosts for previously named taxa, we also offer 6 new combinations (in *Corneromyces, Distophragmia, Polyporus, Pseudolagarobasidium,* & *Vararia),* a convincing argument that *Kriegeria* is a legitmate basidiomycete (not ascomycete) name, a revival of a 'forgotten' name for a common western North American pholiota, and a re-description of a rare *Mycorrhaphium.*

As we noted in Mycotaxon 129(2) (the 2014 October–December issue), our journal is temporarily without a permanent book review editor. Nonetheless, Else Vellinga has generously returned to serve as a guest editor in this issue. Thanks yet again, Else!

Nomenclature of authors and authorities— As an international journal that publishes papers in English, Mycotaxon is not immune to nomenclatural confusion across international borders, particularly when it comes to distinguishing the given or generational names from the surname—that all-important 'family' name that determines which of several names will be spelled in full in abbreviated bibliographic references. We usually manage to decipher the author names correctly, although it usually takes us one to two months to override the stubborn Ingenta algorithm that insists on listing all Brazilian and Portuguese names following the Spanish convention.

Asian names — in particular Chinese, Korean, and Vietnamese — present a special challenge. For over two years, we have incorrectly displayed one author's name, unfortunately for Nguyen Anh Dzung (as it appears in proper Vietnamese). Prof. Nguyen first served as co-author in Mycotaxon 117, where his name appeared as Anh Dzung Nguyen (properly abbreviated and indexed

as Nguyen AD). Unaccustomed to seeing his name in the 'English' style, Prof. Nguyen contacted us to say that his name was Nguyen Anh Dzung. Although well aware that Nguyen is a common Vietnamese surname, we did not know whether it could also serve as a given name. Thus Mycotaxon followed the author's wishes by displaying his name in his next four papers in the Vietnamese order and indexing his name as Dzung NA. With this issue, however, we establish that Nguyen is, in fact, his surname. With past sins corrected in the Errata on p. viii, Prof. Nguyen has kindly agreed to follow our 'English' policy in all future papers.

Other confusions surround how to abbreviate or decode the name of a nomenclatural authority. Mycotaxon asks its authors to adhere to the Index Fungorum list of author abbreviations covering researchers who have previously named fungi. This web-accessible list is handy both for authors and for readers needing to decode the abbreviations of the authorities that stand after the names of taxa in a full scientific name. An author proposing a new taxon for the first time need use initials before the surname ONLY if previous authorities have had the same surname. [I consider being known only as 'Norvell' both simpler and a bit of an honor!] Those who find that their surname has already been 'taken' should follow the established abbreviation (e.g., 'Sm.' for 'Smith'), and add their initials. In instances where two authors share the same initials, then one of the given names should be spelled out. Where nomenclatural authors share all the same names, they are separated by 'bis' (for 2), 'tertia' (for 3), and so on. Be forewarned — as botanists, phycologists, and mycologists are governed by the same code, each surname can stand alone only once. Which explains why the late Meinhard Moser is designated by 'M.M. Moser' and not simply Moser, which refers to the economic botanist Heinrich Christoph Moser, active around 1794.

What's in a name, indeed?

Warm regards,

Lorelei L. Norvell (*Editor-in-Chief*)
30 June 2015

## Four steps to successful Mycotaxon publication in 2015

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3—Final submission: Consult experts, revise and thoroughly proof manuscripts, and prepare error-free text and image files ready for immediate publication. Then send the (i) completed 2015 Mycotaxon submission form; (ii) separate text files for main text, tables, and legends; and (iii) art files to the *Editor-in-Chief* <editor@mycotaxon.com>. The *Editor-in-Chief* usually Emails all coauthors and expert reviewers within two weeks of final submission, but please wait at least 14 days before sending a follow-up query (without attachments); this helps us keep Email traffic to a minimum during Mycotaxon publication deadlines or temporary closures of the editorial office.

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# A new species of *Neosporidesmium* from Hainan, China

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Abstract — *Neosporidesmium diaoluoshanense* sp. nov., collected on rotten branches from tropical forest of Hainan Province, China, is described and illustrated. It differs from previously described *Neosporidesmium* species in producing conidia that possess a colourless, globose, mucilaginous sheath at the apex.

Key words — asexual fungi, key, taxonomy

## Introduction

The genus *Neosporidesmium* was established by Mercado & Mena (1988) for a single species, *N. maestrense*. Subsequently seven other species have been described: *N. sinensis* and *N. microsporum* (Wu & Zhuang 2005); *N. antidesmatis, N. malloti,* and *N. xanthophylli* (Ma et al. 2011a); *N. micheliae* (Zhang et al. 2011a); and *N. vietnamense* (Mel'nik & Braun 2013). The genus is characterized by effuse, dark brown to black, hairy colonies, unbranched conidiophores aggregating into erect, cylindrical, dark brown to black synnemata and integrated, terminal, monoblastic, lageniform or doliiform, determinate or percurrently proliferating conidiogenous cells that produce solitary, pale brown to brown, obclavate or cylindrical, smooth, distoseptate conidia. The criteria used for species delimitation are mainly based on proliferations of conidiogenous cells, conidial morphological characteristics, and conidiomatal overall size (Mercado & Mena 1988, Wu & Zhuang 2005).

The tropical forests of southern China have a rich mycobiota, and many new species have been discovered there (Zhang et al. 2009a,b, 2011b, Ma et al. 2011a,b, 2012). During a continuing investigation on saprobic microfungi from tropical forest of Hainan Province, a morphologically distinct species of *Neosporidesmium* was found. It is proposed here as a new species.

***Neosporidesmium diaoluoshanense*** Xiang Y. Li & X.G. Zhang, **sp. nov.** Fig. 1

MycoBank MB 812118

Differs from other *Neosporidesmium* species in its conidia having an apical, colourless, globose, mucilaginous sheath.

Type: China, Hainan Province: Diaoluoshan Nature Reserve, on rotten branches of an unidentified tree, 10 Apr. 2014, H.X. Dong (**Holotype** HSAUP H7562; **isotype**, HMAS 243460).

Etymology: in reference to the type locality.

Colonies on the natural substrate effuse, solitary, dark brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of dark brown to black, septate, cylindrical hyphae. Conidiomata synnemata, indeterminate, scattered, erect, up to 605 μm high, 40–60 μm wide, composed of straight, unbranched, septate, smooth, brown to dark brown conidiophores 3–6 μm wide, diverging terminally and laterally. Conidiogenous cells monoblastic, integrated, determinate, smooth, cylindrical, doliiform or lageniform, brown to dark brown, 4–10 × 9–15 μm. Conidial secession schizolytic. Conidia solitary, acrogenous, obclavate, base truncate, 8–11-distoseptate, 105–135 × 10.5–13.5 μm, 2.5–3.5 μm wide at the truncate base, rounded at the apex, dry, smooth-walled, pale brown, but hyaline at the apical cells, with an apical, globose, hyaline, 10.5–13.5 μm diam., mucilaginous sheath.

Comments – *Neosporidesmium diaoluoshanense* differs from all previously described species in the genus by producing conidia with an apical, globose, mucilaginous, hyaline sheath and having scattered synnemata. The new species resembles *N. micheliae*, which differs by having conidia with fewer septa (7–8) and lacking a mucilaginous sheath.

**Key to *Neosporidesmium* species**

1. Conidiogenous cells with percurrent proliferation ..... 2
   Conidiogenous cells without percurrent proliferation ..... 4
2. Conidia nearly cylindrical ..... *N. microsporum*
   Conidia obclavate ..... *3*
3. Conidia with filiform beak ..... *N. antidesmatis*
   Conidia without beak ..... *N. maestrense*
4. Synnemata scattered ..... 5
   Synnemata not scattered ..... 6
5. Conidia distoseptate ..... *N. diaoluoshanense*
   Conidia euseptate ..... *N. micheliae*
6. Conidia with beak ..... 7
   Conidia without beak ..... *N. malloti*
7. Conidia euseptate ..... *N. vietnamense*
   Conidia distoseptate ..... 8

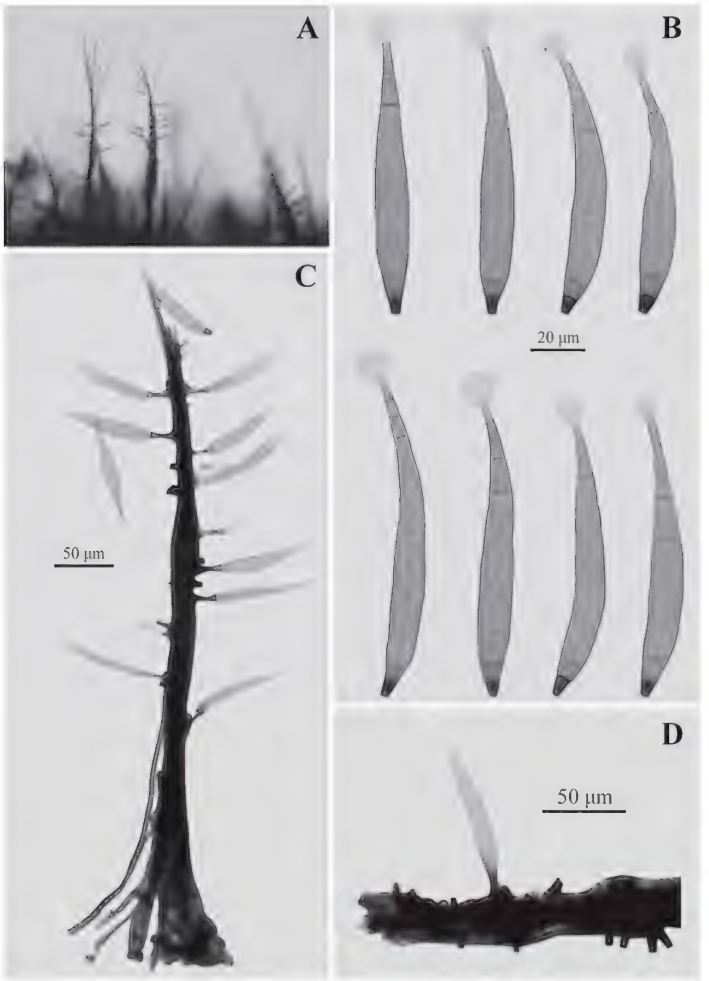


Fig. 1. *Neosporidesmium diaoluoshanense*. A. Synnemata on natural substratum. B. Conidia with an apical, hyaline, globose, mucilaginous sheath. C, D. Synnemata with conidiophores and conidia.

8. Conidia with 6–10 distosepta ..... *N. xanthophylli*
Conidia with 10–11 distosepta ..... *N. sinensis*

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The authors express gratitude to Dr. Eric H.C. McKenzie and Dr. R.F. Castañeda Ruiz for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of

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Zhang YD, Ma J, Ma LG, Castañeda-Ruiz R.F, Zhang XG. 2011a. New species of *Phaeodactylidium* and *Neosporidesmium* from China. Sydowia 63: 125–130.

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# A new species of *Matsushimiella* from submerged leaves in the Brazilian Amazon Forest

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Abstract—*Matsushimiella paraensis* sp. nov. is described and illustrated from specimens collected on submerged leaves in a stream, from Pará, Brazil, in the Amazon rainforest. The fungus is characterized by polyblastic sympodially extending conidiogenous cells and ellipsoid, long ovoid to broadly oblong, 2–4-distoseptate medium to golden brown smooth conidia with a pale brown to subhyaline basal frill left by rhexolytic conidial secession.

Key words— taxonomy, freshwater fungi, tropics

## Introduction

During a mycological survey of conidial fungi occurring on submerged decaying plant remnants from the Amazon rainforest in Brazil (Monteiro et al 2014a,b), an interesting fungus was collected on submerged leaves. Its conidiogenesis and conidial features clearly suggest a placement in the hitherto monotypic genus *Matsushimiella* R.F. Castañeda & Heredia (Castañeda-Ruiz et al. 2001). However, there are remarkable conidial differences distinguishing *Matsushimiella queenslandica* (Matsush.) R.F. Castañeda & Heredia, the type species of the genus, and the new collections from Brazil.

## Material & methods

Samples of submerged litter were placed in paper and plastic bags, taken to the laboratory, and treated according to Castañeda-Ruiz (2005). Mounts were prepared in PVL (polyvinyl alcohol, lactic acid, and phenol) and measurements were taken at ×1000.

Micrographs were obtained with an Olympus microscope (model BX51) equipped with bright field and Nomarski interference optics. The holotype and an additional specimen are deposited in the Herbarium of Universidade Estadual de Feira de Santana, Brazil (HUEFS).

## Taxonomy

***Matsushimiella paraensis*** J.S. Monteiro, R.F. Castañeda & Gusmão, **sp. nov.** Fig.1

MycoBank MB 807635

Differs from *Matsushimiella queenslandica* by its larger, ellipsoid, long ovoid to broad oblong, 2–4-distoseptate conidia.

Type: Brazil, Pará State, Belém, Parque Estadual do Utinga, 1°25′S 48°27′W, on submerged leaves of an unidentified plant in a stream, 9 Jan. 2013, coll. J.S. Monteiro (**Holotype**: HUEFS 210425).

Etymology: Latin *paraensis* refers to Pará State, where the type specimen was collected.

Colonies on the natural substrate effuse, hairy, smooth, golden brown. Conidiophores distinct, unbranched, erect, cylindrical below, geniculate above, 5–10-septate, smooth, wall somewhat thickened, up to 1.5 µm wide, dark brown at the base, pale brown toward the apex, smooth, 170–220 × 5–8 µm. Conidiogenous cells integrated, terminal, geniculate, with several sympodial extensions, polyblastic, pale brown, 40–70 × 4–5 µm. Separating cells more or less cylindrical, subhyaline, 3–4 × 2–2.5 µm, fracturing and remaining as a persistent short peg. Conidial secession rhexolytic. Conidia solitary, acropleurogenous, ellipsoid, long ovoid to broadly oblong, 2–4-distoseptate, mostly 4-distoseptate, 20–25 × 8–10 µm, wall 1–1.5 µm thick, smooth, mid brown or golden brown, fimbriate at the base, frill subhyaline to pale brown, 1–2 µm long, 2–2.5 µm wide.

Additional specimen examined: **BRAZIL**, **Pará**, Parque Estadual do Utinga, 1°25′S 48°27′W, on submerged leaves of an unidentified plant in a stream, 17 Oct. 2012, coll. J.S. Monteiro (HUEFS 210427).

Note: *Matsushimiella* is typified by *M. queenslandica* (Castañeda-Ruiz et al. 2001) based on *Pseudospiropes queenslandica* Matsush., which was collected from decaying leaves of an unidentified plant in Australia. The existence of the separating cells was mentioned in the brief discussion by Matsushima (1989), but not described in the original description of *Matsushimiella* (Castañeda-Ruiz et al. 2001). Seifert et al. (2011) characterized the conidiogenous cells as polytretic, which refers to the original description of *Matsushimiella* (Castañeda-Ruiz et al. 2001). However, conidiogenesis is holoblastic, with mostly polyblastic conidiogenous cells. *Matsushimiella queenslandica* is readily distinguishable from the new Brazilian species by its obovate, 1–3-, mostly 2-distoseptate, 9–16 × 6–8 µm, smooth, pale brown conidia that secede by rhexolytic fracture of cylindrical separating cells.

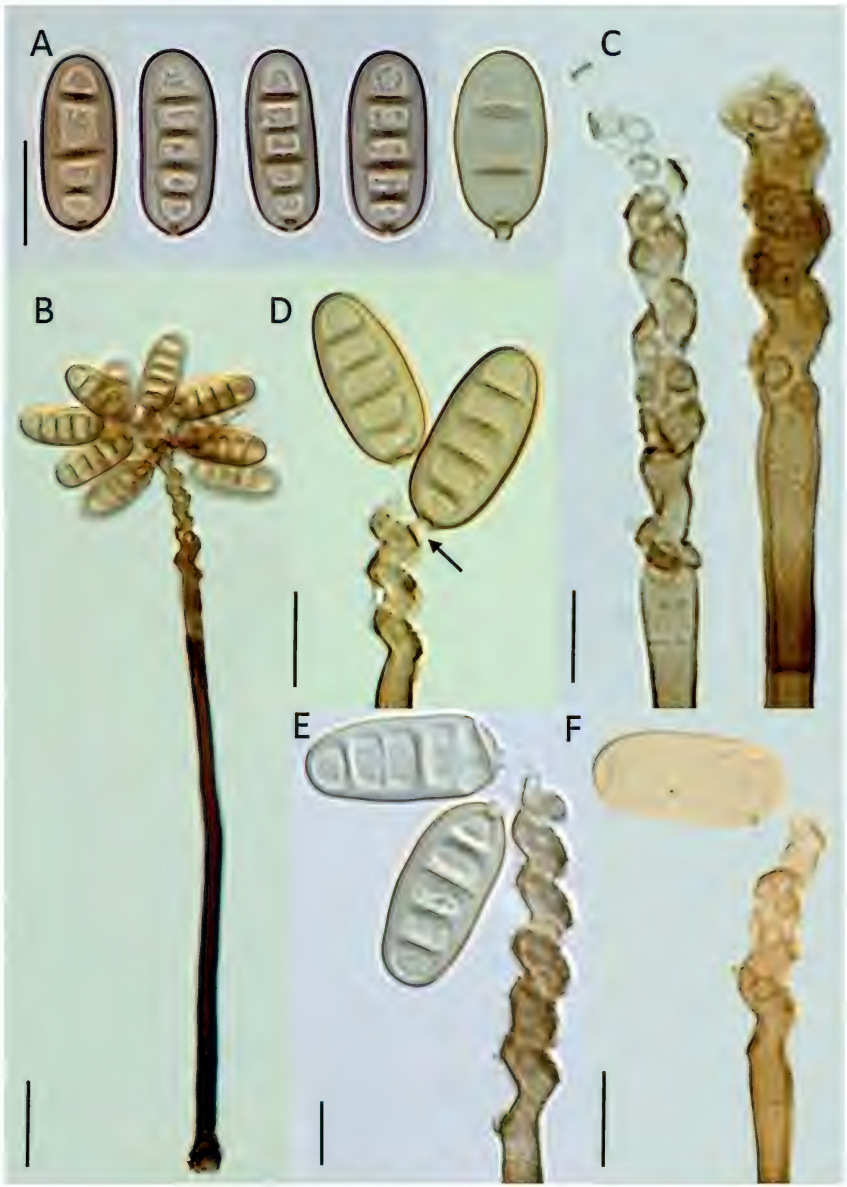


Fig. 1. *Matsushimiella paraensis* (holotype HUEFS 210425): A. Conidia. B. Conidiophore, conidiogenous cell, separating cells, and conidia. C. Conidiogenous cells. D–F. Conidiogenous cells, separating cells (arrow), and conidia. Scale bars = 10 μm.

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# Amazonian phalloids: new records for Brazil and South America

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Abstract — Recent field trips in the Amazonian rainforest revealed two uncommon phalloid species, *Lysurus arachnoideus* (new for Brazil) and *Phallus cinnabarinus* (new for South America). Detailed morphological descriptions, photos, and taxonomic remarks are presented.

Key words — gasteroid fungi, *Lysuraceae,* Neotropics, new records, *Phallaceae*

## Introduction

Corda (1842) proposed the family *Lysuraceae* (as "Lysuroidea") when he segregated the genera *Lysurus* Fr. and *Aseroe* Labill. from *Clathraceae.* Though many authors did not accept *Lysuraceae* (Cunningham 1944, Zeller 1949, Dring 1980), Hosaka et al. (2006) showed that *Lysuraceae* is phylogenetically more closely related to *Phallaceae* than to *Clathraceae,* and considered it an independent family, comprising the single genus *Lysurus* Fr., originally proposed to accommodate *L. mokusin* (Fries 1823).

Kirk et al. (2008) accept five species in *Lysurus,* although Index Fungorum lists 41 names for the genus. Diagnostic morphological features for *Lysurus* include a long stipe with a distinct fertile portion consisting of arms or vertical columns that are united or free or that form a network and a gleba lying on the inner surface of each arm or column (Dring 1980, Trierveiler-Pereira et al. 2014).

The genus *Phallus* Junius ex L. includes species recognized by their phallic shape that comprises an immature basidioma enclosed in a volva that breaks

with maturity and from which emerges a pseudostipe with a fetid mucilaginous gleba. *Phallus* species are widely distributed, but Kreisel (1996) indicated that the center of diversity is China and Southeast Asia.

Thirteen *Phallus* records and five *Lysurus* species are currently recognized from Brazil (Trierveiler-Pereira & Baseia 2009, Cortez et al. 2011); some doubtful taxa have also been reported. This paper contributes to the taxonomic knowledge of phalloid diversity in Amazonia.

## Materials & methods

The specimens were collected during field trips in Brazilian Amazonian rainforests (Careiro, state of Amazonas, Brazil) and French Guiana (Cayenne), where ecological notes and photographs were taken. Morphological measurements were taken from fresh and dried specimens according to Dring (1980) and Cortez et al. (2011). Color descriptions follow Kueppers (1982). Microstructures were measured after rehydration in KOH 5%, with 20 measurements made randomly for each structure using a Leica DM 2500 microscope. Spore and hyphal images were captured with a coupled EC3 camera and Leica Application suite v.2.1.0 software. The specimens were deposited at the Instituto Nacional de Pesquisas da Amazônia Herbarium, Manaus, Amazonas, Brazil (INPA).

## Taxonomy

***Lysurus arachnoideus*** (E. Fisch.) Trierv.-Per. & Hosaka, Mycologia 106: 909, 2014. FIG. 1

≡ *Aseroe arachnoidea* E. Fisch., Denkschr. Schweiz. Naturf. Ges. W.S. Lee, Mycologia 32(1): 76, 1890.

EGGS 15–20 mm diam., globose to subglobose, pale yellow (N00Y20M00), semi-hypogeous, thin rhizomorphs present. EXPANDED BASIDIOMATA 40 × 11 mm. Volva 27–21 mm wide, white (A00M00C00) to pale yellow (N00Y20M00), outer layer composed of filamentous hyphae 4.6–6.4 µm wide, septate with clamp connections, inner layer gelatinous, composed of 4–5.5 µm wide filamentous hyphae. Pseudostipe 12 × 11 mm, cylindrical, white (A00M00C00); surface rugose, hollow, ending in a central perforated disc; composed of globose to subglobose pseudoparenchymatous hyphae, 70 µm diam., hyaline in 5% KOH. Receptacle formed by a disc with 9 arms developing from the margins. Arms up to 18 mm long, not cylindrical, hollow and consisting of a single tube, white (A00M00C00), inner surface rugose, covered by the gleba up to 2/3 of the arm length. Gleba olive brown (N99A50M10), fetid. BASIDIOSPORES 3.5–4.4 × 2.1–2.5 µm, ellipsoid, smooth, greenish in 5% KOH.

ECOLOGY & DISTRIBUTION: Hosaka (2010) reports *L. arachnoideus* from Africa, Thailand, Japan, China, Indonesia, Sri Lanka, and Malaysia.

SPECIMENS EXAMINED — **BRAZIL. AMAZONAS: Careiro,** Purupuru community, 3°22.96′S 59°42.63′W, in dung, in an ombrophilous dense forest fragment, 7.II.2013, T.S.

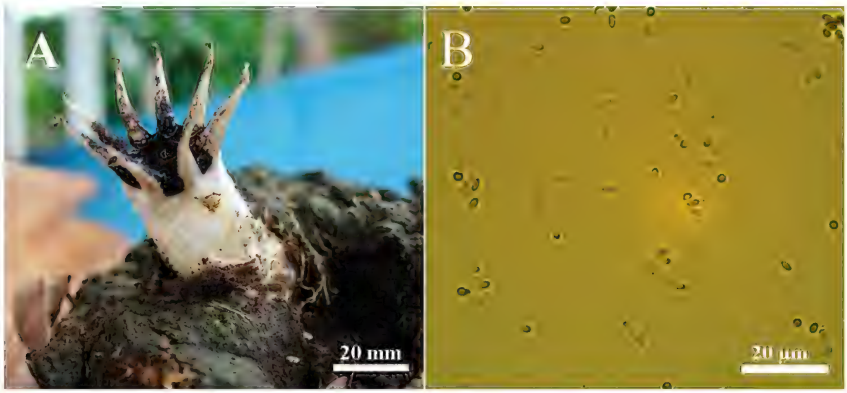


FIGURE 1. *Lysurus arachnoideus* (INPA 256537). A: Expanded basidioma. B: Basidiospores.

Cabral 41 (INPA 256537; Genbank KJ764820). **JAPAN. TOTTORI: Kokoje**, 1.IX.1980, T. Hongo & E. Nagasawa (TMI 6927); 5.IX.1980, E. Nagasawa (TMI 6929); 9.IX.1980, E. Nagasawa (TMI 6930); 22.IX.1983, I. Arita (TMI 11622).

COMMENTS — *Lysurus arachnoideus* sensu lato was previously recorded only once from South America, by Fischer (1928), who described a new variety (*Aseroe arachnoidea* var. *americana*) based on a specimen collected in Suriname, which apparently differed from *A. arachnoidea* var. *arachnoidea* mainly by the arms being arranged in pairs. Unfortunately Fischer (1928) did not provide a detailed description or include microstructure sizes. Our specimen has unpaired arms (FIG. 1A), and the spore size matches an African specimen described by Dring (1964). The taxonomically significant characters do not vary significantly between the Brazilian and the Japanese specimens. The Japanese material has a pseudostipe and arms longer than the Brazilian specimen, pseudoparenchymatous hyphae that are up to 76 µm diam., and smooth spores that are up to 4 µm long. Despite these differences, we prefer to maintain our collection as *L. arachnoideus* (instead of *A. arachnoidea* var. *americana* E. Fisch.) based on the morphological characters until further molecular analyses can be carried out.

Our Amazonas specimen represents the second record for South America and the first for Brazil.

***Phallus cinnabarinus*** (W.S. Lee) Kreisel, Czech Mycol. 48: 278, 1996. FIG. 2

≡ *Dictyophora cinnabarina* W.S. Lee, *Mycologia* 49: 156, 1957.

EGGS 24–23 mm wide, ovoid to subglobose, pale yellow (N10A10M00) to brown (N60A90M00), with thick and lilac to pink rhizomorphs. EXPANDED BASIDIOMATA 192 mm high. Receptacle 34 high × 70 mm wide, bright orange (N10A70M70), campanulate, with an apical pore, surface reticulate.

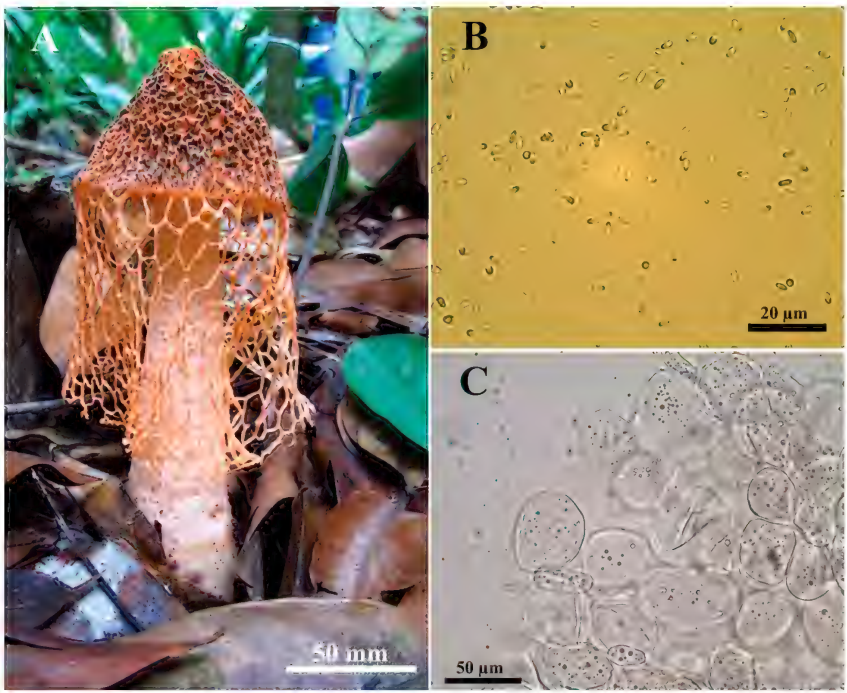


FIGURE 2. *Phallus cinnabarinus* (INPA 255835). A: Expanded basidioma. B: Basidiospores. C: Pseudoparenchymatous hyphae of pseudostipe with pinkish pigment droplets.

Pseudostipe 130 × 23 mm, cylindrical, spongy, pale pink (N10A40M30), composed of globose to subglobose pseudoparenchymatous hyphae, 40–67 µm diam., hyaline in 5% KOH, pinkish pigment droplets present. Volva pale yellow (N10A10M00), outer layer cottony, composed of filamentous hyphae 3–4 µm diam., sinuous, septate, clamp connection present; inner layer gelatinous, composed of filamentous hyphae 2.2–3 µm diam., hyaline in KOH 5%; basal portion with rhizomorphs. Indusium extending to half of pseudostipe, bright orange (N10A80M50), 69 mm long, polygonal meshes up to 9 mm, formed of globose to subglobose hyphae, 24–66 µm diam., pinkish pigment droplets present. Gleba brown (N60A90M40), mucilaginous. BASIDIOSPORES 2.8–4.2 × 1.2–1.9 µm, ellipsoid, smooth, olive brown in 5% KOH.

ECOLOGY & DISTRIBUTION — Kreisel (1996) first described *Phallus cinnabarinus* from Taiwan (Kreisel 1996), but it has since been reported from many parts of the world (Hemmes & Desjardin 2009).

SPECIMENS EXAMINED — **BRAZIL, PARÁ: Belém,** Jardim Botânico Bosque Rodrigues Alves, 1°25.83′S 48°27.30′W, on soil among grasses and at the base of bamboo clumps, 27.XI.2013, T.S. Cabral 81 (INPA 255835; Genbank KJ764821); Museu Paraense Emílio

Goeldi, 1°27.55′S 48°28.60′W, 28.XI.2013, T.S. Cabral 82 (INPA 255836). **FRENCH GUIANA: Cayenne,** in grounds of the Herbier de Guyane (CAY), Institut de Recherche pour le Developpement (IRD), 4°56.35′N 52°17.21′W, 11.III.2013, Cabral TS 48 (INPA 255837).

Comments — There is controversy involving two morphologically similar *Phallus* species: *P. multicolor* (Berk. & Broome) Cooke and *P. cinnabarinus*. *Phallus multicolor* [≡ *Dictyophora multicolor* Berk. & Broome] was originally described as having a lemon-yellow indusium, an orange receptacle, and spores up to 5 µm (Berkeley & Broome 1883), while *P. cinnabarinus* was described with a cinnabar-red receptacle and indusium, volva with pinkish rhizomorphs at base, and spores up to 4 µm (Lee 1957). Considering the original descriptions, we believe that the specimens analysed here represent *P. cinnabarinus*, based mainly on the cinnabar-red color of the indusium and receptacle, spores smaller than in *P. multicolor*, and divergence in rhizomorph colours. Cunningham (1944) described an Australian specimen of *Phallus multicolor*, mentioning a salmon-pink indusium, orange receptacle, volva with short soft spines, and basidiospores up to 4.5 µm long. Reporting *P. multicolor* from India, Dutta et al. (2012) cited a lemon-yellow indusium, lemon-yellow to yellowish orange receptacle, and different basidiospore size. Although Hemmes & Desjardin (2009) provide good photos of both species that illustrate the primary macroscopic differences (indusium and receptacle colours) between the two species, unfortunately, a detailed description of *P. multicolor* cannot be found in the recent literature.

There is no previous record of *P. cinnabarinus* for South America. Cheype (2010) reported *P.* aff. *multicolor* from French Guiana, but he does not mention a herbarium voucher, which prevents further comparative analysis. A *Phallus* specimen collected on a recent field trip to French Guiana enabled a comparative study that confirmed the conspecificity of the French Guianan and Brazilian collections as *P. cinnabarinus*.

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# On the generic names *Kriegeria*

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Abstract — The basidiomycetous genus *Kriegeria* Bres. 1891 (*Kriegeriaceae*), typified by *K. eriophori*, is legitimate. An ascomycetous genus "*Kriegeria*" was originally published by Rabenhorst in 1876 as an invalid provisional name based on *Ombrophila kriegeriana*. Subsequently, the ascomycetous genus was validly published as *Kriegeria* Höhn. 1914 (*Rutstroemiaceae*), typified by *Peziza elatina*; this genus is an illegitimate later homonym, currently treated as a synonym of *Rutstroemia*. Additionally, Rabenhorst's invalid name was "revived" (validated) as *Kriegeria* Rabenh. ex Seaver 1943, typified by *O. kriegeriana*, to accommodate species currently placed in *Chloroscypha*. Revised nomenclators are presented for both of the genera, as well as for *Ombrophila kriegeriana*.

Key words — *Helotiales, Kriegeriales, Leotiomycetes, Microbotryomycetes, Xenogloea, Zymoxenogloea*

## Introduction

Two different genera have been named as *Kriegeria*. The citation of one of these, the basidiomycetous genus *Kriegeria* published by Bresadola (1891), is uncontroversial. However, the correct citation of the ascomycetous genus *Kriegeria* has been the subject of long-standing debate, attributed either to Rabenhorst (1876, 1878a) or to Höhnel (1914); and consequently, the basidiomycetous *Kriegeria* Bres. has been considered to be either an illegitimate later homonym, or a legitimate earlier homonym. The basis of this controversy is whether *Kriegeria* Rabenh. is a validly published alternative name, or an invalid provisional name. We have conducted an extensive literature survey and nomenclatural analysis to resolve this problem.

## *Kriegeria* Höhn. (*Rutstroemiaceae, Helotiales, Leotiomycetes*)

*Kriegeria* Höhn., Sitzungsber. K. Akad. Wiss., Math.-Naturwiss. Kl., Abt. 1, 123: 114. 1914, nom. illeg., non Bres. 1891.

Type: *Peziza elatina* Alb. & Schwein. : Fr., Consp. Fung. Lusat.: 330. 1805.

= ***Rutstroemia*** P. Karst., Bidr. Känn. Finl. Nat. Folk 19: 12. 1871.
TYPE: *Peziza firma* Pers. : Fr., Syn. Meth. Fung.: 658. 1801.
= *Kriegeria* Rabenh. ex Seaver, Mycologia 35: 492. 1943,
nom. illeg., non Bres. 1891, nec Höhn. 1914.
["*Kriegeria*" Rabenh., Fungi Europ. Exsicc. 24: no. 2315. 1876, nom. prov.]
TYPE: *Ombrophila kriegeriana* Rabenh., Fungi Europ. Exsicc. 24: no. 2315. 1876.

*Ombrophila kriegeriana* Rabenh., Fungi Europ. Exsicc. 24: no. 2315. 1876.
["*Kriegeria olivacea*" Rabenh., Fungi Europ. Exsicc. 24: no. 2315. 1876, nom. prov.]
≡ *Ciboria kriegeriana* (Rabenh.) Rehm, Hedwigia 22: 36. 1883.
≡ *Chlorosplenium kriegerianum* (Rabenh.) Sacc., Syll. Fung. 8: 318. 1889.
≡ *Kriegeria kriegeriana* (Rabenh.) Seaver, Mycologia 35: 493. 1943.
= *Peziza elatina* Alb. & Schwein. : Fr., Consp. Fung. Lusat.: 330. 1805.
≡ *Helotium elatinum* (Alb. & Schwein. : Fr.) Quél., Ench. Fung.: 309. 1886.
≡ *Chlorosplenium elatinum* (Alb. & Schwein. : Fr.) Sacc., Syll. Fung. 8: 318. 1889.
≡ ***Rutstroemia elatina*** (Alb. & Schwein. : Fr.) Rehm, Rabenh. Krypt.-Fl.,
Ed. 2, 1(3): 767. 1893.
≡ *Kriegeria elatina* (Alb. & Schwein. : Fr.) Höhn., Sitzungsber. K.
Akad. Wiss., Math.-Naturwiss. Kl., Abt. 1, 123: 114. 1914.

The critical publication concerning the ascomycetous *Kriegeria* is the protologue of *Ombrophila kriegeriana* (Rabenhorst 1876). This printed exsiccata label presents a Latin description, Latin collection data [Königstein, Saxony, on *Abies* twigs], a paragraph of German "Obs.", and the author's initials "L.R." In the Observations, Rabenhorst noted: (1) that the specimens are immature, creating some doubt whether *Ombrophila* is the appropriate genus [indicated by inclusion of a question mark after the genus name in the binomial proposal]; (2) that the collector, W. Krieger, will endeavor to collect more material with mature ascomata; (3) that the species may require the proposal of a new genus for which he would suggest the name *Kriegeria*; (4) that in this potential new genus, he would suggest the epithet *olivacea*. He did not combine the genus and epithet into an explicit binomial (Seaver 1943 appears to be the first author to assemble the binomial). Considered as a whole, the Observations do not suggest that "*Kriegeria olivacea*" was being formally proposed as an alternative name for *Ombrophila kriegeriana*, but that it was merely being suggested as a provisional name to be taken up in the future if mature specimens justified the proposal of a new genus. "*Kriegeria*" Rabenh. and "*Kriegeria olivacea*" Rabenh. are therefore invalid names (McNeill et al. 2012: Art. 36.1(b)).

This situation is somewhat obscured in Rabenhorst (1878a), where the *Ombrophila kriegeriana* protologue is reproduced verbatim, but with the first two sentences of the Observations omitted; i.e., there is no mention of the immaturity of the specimens nor of Krieger's intention to look for mature material. (Nevertheless, when Donk (1958) reached his firm decision that

"*Kriegeria*" Rabenh. was a provisional name, it was this reference that he cited and its abbreviated version of the original Observations that he quoted.) Because Rabenhorst (1878a) has been widely (but erroneously) accepted as the protologue of *O. kriegeriana*/"*K. olivacea*", several mycologists have misunderstood "*Kriegeria olivacea*" to have been proposed as a valid alternative name. It is significant that the Index of Names for Hedwigia vol. 17 (Rabenhorst 1878b: p. V) does not list either "*Kriegeria*" or "*Kriegeria olivacea*". Rabenhorst died on 24 April 1881, presumably before Krieger had collected or sent any mature specimens.

Winter (1881: 70–71) commented on *Ombrophila kriegeriana*, reporting that he had often seen it during spring in Zürich. On the basis of his own observations and Rabenhorst's description, Winter concluded that *O. kriegeriana* was a synonym of *Peziza elatina* Alb. & Schwein.; he made no mention of the names "*Kriegeria*" and "*Kriegeria olivacea*".

*Ombrophila kriegeriana* was recombined in *Ciboria* by Rehm (1883: 36–37) and in *Chlorosplenium* by Saccardo (1889: 318). Both authors mentioned Winter's proposed synonymy with *Peziza elatina* (without accepting it), but neither of them mentioned the names "*Kriegeria*" and "*Kriegeria olivacea*".

Rehm (1893: 767) recombined *Peziza elatina* in *Rutstroemia* (the genus in which this species is currently accepted). Rehm's *R. elatina* nomenclator included *Ombrophila kriegeriana* and its *Ciboria* and *Chlorosplenium* recombinations as synonyms, but it did not include "*Kriegeria olivacea*" (even though Rabenhorst's suggestion of this genus and this epithet are annotated in Rehm's synopsis of the literature).

Höhnel (1914: 112–114) was the first author to validate the ascomycetous genus *Kriegeria*, but his treatment is full of errors:

(1) Höhnel attributed the genus to "Winter (Hedwigia, 1878, 17. Bd., p. 32)";

(2) he stated that *Peziza elatina* was transferred to *Kriegeria* by "Winter (Hedwigia, 1878, 17. Bd., p. 32)"; and

(3) he stated that the generic type was "*Kriegeria elatina* (A. u. S.) Winter".

The cited Hedwigia reference has no connection with Winter and is, in fact, Rabenhorst (1878a), which contains no mention of *Kriegeria elatina* or its basionym *Peziza elatina*. Rabenhorst edited the first ten issues of Hedwigia vol. 17 (pp. 1–160, January–October 1878), and Winter's editorship did not commence until issue 11 (November 1878). (Likewise, Winter did not assume editorship of Fungi Europaei Exsiccati until late 1881, after Rabenhorst's death.) We have scrutinized all of Winter's publications from 1878 until his death in 1887 and can find no mention of either "*Kriegeria*" or "*Kriegeria elatina*"; his only relevant publication was Winter (1881) where he synonymized *Ombrophila kriegeriana* under *Peziza elatina* (as discussed above). *Kriegeria*

Höhn. cannot be treated as a validation of "*Kriegeria*" Rabenh., because they have different (albeit conspecific) generic types, *Peziza elatina* [≡ *K. elatina*] versus "*K. olivacea*". Consequently, Höhnel's (1914) *Kriegeria* and *K. elatina* must be interpreted as a gen. nov. and a comb. nov. attributable to Höhnel alone (not to "Rabenh. ex Höhn.", and definitely not to "G. Winter ex Höhn."). *Kriegeria* Höhn. 1914 is an illegitimate later homonym of the basidiomycetous *Kriegeria* Bres. 1891 — a genus that Höhnel himself (1909: 1157–1159) had apparently accepted as legitimate. Höhnel (1914) included a second species, *Kriegeria urceolus* (Fuckel) Höhn. [≡ *Rutstroemia urceolus* (Fuckel) W.L. White (White 1941; Whetzel 1945)].

In his monographic treatment of *Rutstroemia*, White (1941) included the erroneous synonym "*Kriegeria* Wint. Hedw. 17: 32, 1878" (copied from Höhnel 1914) in his generic nomenclator. He accepted the full *R. elatina* nomenclator published by Rehm (1893), including *O. kriegeriana* and its recombinations, but he added the fictitious "*Kriegeria elatina* Wint. Hedwigia 17: 32, 1878" (also copied from Höhnel 1914).

Seaver (1943) proposed to "revive" the Rabenhorst genus "*Kriegeria*", typified by *Ombrophila kriegeriana*, which he recombined as *Kriegeria kriegeriana*. Because of its different type, Seaver's genus must be interpreted as an additional later homonym, *Kriegeria* Rabenh. ex Seaver, a heterotypic synonym of *Kriegeria* Höhn. Seaver's paper has several puzzling aspects. Inexplicably, he cited two different "protologue" references: "Rab. Fungi Eur. 2315. 1878 [sic]" (i.e., Rabenhorst 1876) for *Ombrophila kriegeriana* and "Hedwigia 17: 32. 1878" (i.e., Rabenhorst 1878a) for the genus "*Kriegeria*" and for the species "*Kriegeria olivacea*". Seaver's failure to observe that all three names were actually published simultaneously by Rabenhorst (1876) suggests that he had not seen the *O. kriegeriana* exsiccata label. Significantly, Seaver (1943) did not mention Höhnel's treatment of *Kriegeria* nor Winter's and Rehm's synonymization of *O. kriegeriana* with *Rutstroemia elatina*, and he explicitly rejected White's (1941) placement of *Kriegeria* in *Rutstroemia*. Seaver (1943) synonymized his genus *Kriegeria* with *Chloroscypha* Seaver, and cited the protologue description of *Chloroscypha* (Seaver 1931) as the validating description of *Kriegeria*. In addition to the type (Rabenhorst's immature exsiccata material), Seaver (1943) recombined five other species that had all previously been included in *Chloroscypha* (Seaver 1931, 1938), and two further species were recombined in *Kriegeria* by Seaver (1951). Apart from *Kriegeria kriegeriana* (on a pinaceous host: *Abies*), all of Seaver's *Kriegeria* species (on cupressaceous or taxodiaceous hosts: *Calocedrus*, *Chamaecyparis*, *Cryptomeria*, *Juniperus*, *Thuja*, *Sequoia*) are currently accepted in *Chloroscypha* (Petrini 1982). Seaver seems to have been unaware of the incongruence between *Kriegeria* sensu Höhnel/White [= *Rutstroemia*] and *Kriegeria* sensu Seaver [= *Chloroscypha*].

### *Kriegeria* Bres. (*Kriegeriaceae, Kriegeriales, Microbotryomycetes*)

***Kriegeria*** Bres., Rev. Mycol. (Toulouse). 13: 14. 1891.

≡ *Xenogloea* Syd. & P. Syd., Ann. Mycol. 17: 44. 1919, nom. illeg. (superfluous).

Type: *Kriegeria eriophori* Bres., Rev. Mycol. (Toulouse). 13: 14. 1891.

= *Zymoxenogloea* D.J. McLaughlin & Doublés, Mycologia 84: 671. 1992.

Type: *Zymoxenogloea eriophori* D.J. McLaughlin & Doublés, Mycologia 84: 671. 1992.

Contemporary material of the sole species was distributed as exsiccata specimens (Pazschke 1895; Kohlmeyer 1962). Sydow & Sydow (1919) thought that *Kriegeria* "Winter (cfr. Hedwigia 1878, p. 32)" was a valid name, making the basidiomycetous *Kriegeria* Bres. an illegitimate later homonym, for which they proposed *Xenogloea* as a replacement name. Their miscitation of Winter as the author and Rabenhorst (1878a) as the protologue suggests that they were relying on Höhnel's (1914) treatment rather than carefully considering the original Rabenhorst (1876) protologue. With "*Kriegeria*" Rabenh. being an invalid provisional name, *Kriegeria* Bres. is legitimate and *Xenogloea* is superfluous and illegitimate. Doublés & McLaughlin (1992) treated *Kriegeria* Bres. as a legitimate generic name, and described a new genus *Zymoxenogloea* for the yeast-like anamorphic state. Toome et al. (2013) proposed *Kriegeriaceae* and *Kriegeriales* as a new family and order typified by *Kriegeria* Bres.

#### Discussion

The acomycetous genus *Kriegeria* has been published three times (once invalidly and twice illegitimately):

(1) as "*Kriegeria*" Rabenh. 1876, an invalid provisional name that no mycologist during the next 38 years ever treated as a formal name: its invalid status has been argued by several eminent mycologists, e.g., by Dennis (1954, 1956) and, most persuasively, by Donk (1958), and it is not listed by Kirk et al. (2008) nor by the Index Nominum Genericorum website (ING 2015);

(2) as *Kriegeria* Höhn. 1914, a valid generic name based on a different type, but an illegitimate later homonym (of *Kriegeria* Bres.; ING 2015): it was not taken up by any subsequent mycologist but almost universally accepted as a synonym of *Rutstroemia* (e.g., Rehm 1893, White 1941, Whetzel 1945, Dennis 1956, Kirk et al. 2008) — major errors in Höhnel's protologue have created citational confusion that still persists 100 years later;

(3) as *Kriegeria* Rabenh. ex Seaver 1943, an illegitimate later homonym based on Rabenhorst's invalid name: Seaver's genus was rejected by subsequent mycologists (e.g., Dennis 1954, 1956; Kobayashi 1965; Petrini 1982), who argued that the species included in *Kriegeria* by

> Seaver (1943, 1951) were not congeneric with the type (*Ombrophila kriegeriana* [= *Rutstroemia elatina*]) but instead belonged in *Chloroscypha.* Seaver's *Kriegeria* homonym is not mentioned by Kirk et al. (2008) nor by ING (2015).

There is no legitimately published ascomycetous genus *Kriegeria*, and this name is not in current use.

In contrast, the basidiomycetous *Kriegeria* Bres. 1891 is a legitimate monotypic genus that is predated only by the invalid "*Kriegeria*" Rabenh. 1876. Saccardo (1892: 497) tentatively identified the type as a *Septogloeum,* and Höhnel (1909: 1157–1159) recombined it in *Platygloea*, but subsequently *Kriegeria* Bres. has been accepted as a distinct genus, either under the superfluous replacement name *Xenogloea* (Sydow & Sydow 1919: 44; Weiss 1950: 295; Martin 1952: 88–89; Kao 1956; Bandoni 1957: 838) or as a legitimate *Kriegeria* Bres. (e.g., Davis 1922: 410; Donk 1958: 206; Oberwinkler & Bandoni 1982: 1744; Farr et al. 1989: 753; Doublés & McLaughlin 1992; Fell et al. 2001; Swann et al. 2001; Sampaio & Oberwinkler 2011; Toome et al. 2013). *Kriegeria* is accepted as legitimate, and *Xenogloea* as superfluous, by Kirk et al. (2008) and ING (2015).

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# New records of crustose lichens and a lichenicolous *Arthonia* from Vietnam

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Abstract — New records from Vietnam of the crustose lichen species *Arthonia excipienda*, *Chiodecton leptosporum*, *Graphidastra multiformis*, *Pertusaria pycnothelia*, *P. thwaitesii*, and *Phlyctis uncinata* are presented together with the second world report of the non-lichenized lichenicolous fungus, *Arthonia diorygmae*. All species were collected from the Bidoup Nui Ba National Park located in the central highlands in Vietnam. A taxonomic description of each species is accompanied by distributional and ecological data and illustrations.

Key words — corticolous, Đà Lạt city, evergreen forest, tropical

## Introduction

A lichenological expedition was organized in 2014 by the National Research Foundation of Korea and the Korea National Research Resource Center Program. During fieldwork two of the authors collected a large number of crustose lichens growing predominantly on trees in evergreen forests of the Bidoup Nui Ba National Park in Vietnam. Among the more interesting collections, we report and describe six corticolous species new for the country. New Vietnamese records include *Arthonia excipienda,* first representatives of the genera *Chiodecton* (*C. leptosporum*), *Graphidastra* (*G. multiformis*), and *Phlyctis* (*P. uncinata*), and two new *Pertusaria* species (*P. pycnothelia, P. thwaitesii*) to be added the previously reported *P. asiana* Vain. and *P. pertusa* (L.) Tuck. (Aptroot & Sparrius 2006, Joshi et al. 2014).

The lichenicolous non-lichenized *Arthonia diorygmae* was found parasitizing a thallus of *Diorygma*, where it restricted the growth of the

host ascocarps. Although *Arthonia accolens* Stirt., *A. antillarum* (Fée) Nyl., *A. cinnabarina* (DC.) Wallr., *A. cyanea* Müll. Arg., and *A. microcephala* Vězda have been previously recorded from Vietnam as corticolous and foliicolous species (Aptroot & Sparrius 2006, Nguyen et al. 2011), no lichen-inhabiting fungus has ever been reported from Vietnam in *Arthonia* or any other genus.

## Materials & methods

Morphological features of specimens collected from tropical rain forests of Đà Lạt city in Lam Dong province of Vietnam were examined under Magnus Zoom Stereo Trinocular (MSZ-TR) dissecting microscope and anatomical characters were observed under a compound microscope (Leica DM 500). Chemical spot tests and TLC (using solvent system A) were conducted according to Orange et al. (2010). The studied material is deposited in the herbarium of KoLRI (Korean Lichen Research Institute), South Korea.

## Taxonomy

***Arthonia diorygmae*** S. Joshi & Upreti, Lichenologist 45: 323, 2013. Pl. 1a

Thallus absent, non-lichenized, lichenicolous on *Diorygma;* ascomata dot-like, round, irregular to shortly lirellate, prominent; 0.2–0.3 × 0.1–0.2 mm; proper exciple completely carbonized to dark brown, 15–20 µm wide, in continuation with hypothecium, undulating, V-shaped; epihymenium brown, 15–25 µm high; hymenium hyaline, inspersed with oil droplets, gelatinous, ≤100 µm high, I+ wine red; paraphyses indistinct, 1–1.5 µm thick; asci broadly clavate, 8-spored, 40–50 × 13–15 µm, epiplasm I+ wine red; ascospores hyaline becoming dark brown and warty, 2-celled, ovoid to slipper-shaped, 10–16 × 4–5 µm, I–.

Chemistry: Ascomata (*Arthonia*): K–, PD–, C–. Thallus (*Diorygma* host species): K+ yellow, PD+ yellow-orange, C–; norstictic and stictic acid chemosyndrome detected in TLC of host species.

Distribution & ecology: This is the second report of *A. dorygma,* previously known only from the type locality in India (Joshi et al. 2013b). In Vietnam it was collected at ca. 1400 m from a thick- and smooth-barked tree, where it was growing luxuriantly and spread largely in association with *Cryptothecia*, *Diorygma*, and other graphidaceous taxa.

Specimens examined: **VIETNAM. Lam Dong province:** Bidoup Nui Ba National Park, Đà Lạt city, 12°10′55.4″N 108°40′50.1″E, alt. 1454 m, on tree bark, 7 January 2014, Hur & Oh VN140150, VN140098 (KoLRI).

Remarks: This species is distinctive in having non-lichenized lichenicolous life form. Though, our specimen differs from the *A. diorygmae* type material in also producing stictic acid by the host, all taxonomic characters were similar to those of the holotype described from the Western Ghats in India (Joshi et al. 2013b).

***Arthonia excipienda*** (Nyl.) Nyl., Lich. Scand.: 261, 1861. Pl. 1B

Thallus corticolous, crustose, endoperidermal, smooth, continuous, shiny, pale green to yellowish, thin, 40–60 µm in cross section, corticate; cortex indistinct to 30 µm; photobiont cells chlorococcoid, aggregate to disperse, layer discontinuous, ≤25 µm; medulla indistinct; ascomata lirelliform, sessile; lirellae 0.5–1 × 0.1–0.2 mm; disc slightly open, black, epruinose; thalline margin absent to indistinct; proper exciple laterally carbonized, 25–30 µm wide, convergent, internally lined by 20–60 µm periphysoids; epihymenium brown, 10–15 µm high; hymenium hyaline, clear, gelatinous, 60–70 µm high, I+ blue; hypothecium hyaline to brownish 20–25 µm high; asci broadly clavate, 8-spored, 60–65 × 20–22 µm; ascospores hyaline to brown, 19–21 × 7–8 µm, I–.

Chemistry: K–, PD–, C–; no lichen compounds detected in TLC.

Distribution & ecology: The species was recorded from West European countries and South Korea (Joshi et al. 2013a); in Vietnam, it was found growing poorly at 1400–1500 m in association with other crustose corticolous lichens on smooth-barked trees.

Specimens examined: **VIETNAM. Lam Dong province:** Bidoup Nui Ba National Park, Đà Lạt city, 12°10′55.4″N 108°40′50.1″E, alt. 1454 m, on tree trunk, 7 January 2014, Hur & Oh VN140080 (KoLRI); 12°10′54.6″N 108°40′45.1″E, alt. 1426 m, on tree trunk, 8 January 2014, Hur & Oh VN140167 (KoLRI).

Remarks: *Arthonia excipienda*, an uncommon species in Asia, apparently resembles *A. punctiformis* Ach. and *A. radiata* (Pers.) Ach., which differ in having multiseptate ascospores. *Arthonia didyma* Körb. also produces 2-celled ascospores, but they are brown and warty on maturity.

***Chiodecton leptosporum*** Müll. Arg., Flora 65: 332, 1882. Pl. 1C

Thallus corticolous, crustose, epiperidermal, tightly attached to the substrate, smooth to slightly verruculose, pale green, with a white pruina, 200–400 µm thick in cross section, ecorticate; photobiont cells *Trentepohlia*-like, layer ≤200 µm; medulla whitish with few calcium oxalate crystals, 200–250 µm, mostly endoperidermal; prothallus usually distinct, brownish; ascomata perithecioid, dot-like to round, solitary or rarely united, aggregated into distinctly elevated stroma-like structures usually with more than 10 ascocarps, 0.1–0.2 mm in diameter; stroma round to oval, 0.5–2 mm in diameter; proper exciple dark brown to completely carbonized, 25–45 µm; epihymenium brown, indistinct to 15 µm high; hymenium hyaline, clear, 135–140 µm high, I+ blue; hypothecium extending down to the substrate, hard and black, ≤200 µm high; paraphyses 1–1.5 µm thick; asci clavate, 8-spored, 80–100 × 9–12 µm, I–; ascospores obovate, hyaline, 3-septate, 30–40 × 3–4 µm, I–; locules cylindrical, 7–9 × 1–2 µm.

Chemistry: K–, PD–, C–; roccellic acid detected in TLC.

Distribution & ecology: *Chiodecton leptosporum* is widely distributed in Asia, Australia, and scattered localities in New Caledonia, Fiji, and Guam (Thor 1990); in Vietnam, it was luxuriantly growing at 1400–1500 m on hard-barked trees in an evergreen forest. The other lichens growing in association were unknown leprose taxa and *Cryptothecia*.

Specimens examined: **VIETNAM. Lam Dong province:** Bidoup Nui Ba National Park, Đà Lạt city, 12°10′55.4″N 108°40′50.1″E, alt. 1454 m, on tree bark, 7 January 2014, Hur & Oh VN140043, VN140065, VN140067, VN140078, VN140090 (KoLRI); 12°10′38.9″N 108°40′37.9″E, alt. 1426 m, on tree bark, 8 January 2014, Hur & Oh VN140149 (KoLRI).

Remarks: *Chiodecton leptosporum* can easily be confused with another most commonly distributed *C. congestulum* Nyl., which differs in a thallus containing a yellow pigmented medulla and a hymenium with a feeble iodine reaction. A comparatively rougher thallus and mostly united ascocarps further distinguish *C. congestulum* from *C. leptosporum*.

***Graphidastra multiformis*** (Mont. & Bosch) G. Thor, Opera Bot. 103: 82, 1991.

Pl. 1D

Thallus corticolous, crustose, epiperidermal, tightly attached to the substrate, cretaceous, pale green to greenish grey, 200–300 µm thick in cross section, epinecral layer resembling cortex is present, 80–85 µm; photobiont cells *Trentepohlia*-like, layer ≤120 µm; medulla whitish, with few to numerous calcium oxalate crystals, 100–120 µm; prothallus whitish in inner part and brownish in outer part; ascomata usually lirelliform, but sometimes apothecioid, solitary; apothecioid and lirelliform structures distinctly elevated with a slightly to distinctly constricted base, 1–2 × 0.5–1 mm; disc black, 5–10 mm thick; thalline margin 130–330 µm thick; proper exciple thinly carbonized laterally, 15–20 µm, basally continuous with hypothecium; epihymenium brown, 25–35 µm; hymenium hyaline, clear, 60–85 µm, I+ reddish; hypothecium extending down to the substrate, hard, black, ± V-shaped, 0.3–0.5 mm; paraphyses 1–2 µm thick; asci clavate, 55–60 × 5–6 µm, I+ blue; ascospores hyaline, spermatoid, 3-septate, 35–40 × 2–3 µm (including tail of 20–22 µm), I–.

Chemistry: K–, PD–(?), C–; roccellic acid and traces of protocetraric acid detected in TLC.

Distribution & ecology: *Graphidastra multiformis* has previously been reported from India, Sri Lanka, The Philippines, Australia, West Samoa, and Tahiti (Thor 1990); in Vietnam it was collected at ca. 1400 m from thick- and hard-barked trees, where it was growing luxuriantly along with members of *Pannariaceae* and *Chiodecton leptosporum*.

Specimen examined: **VIETNAM. Lam Dong province:** Bidoup Nui Ba National Park, Đà Lạt city, 12°10′55.4″N 108°40′50.1″E, alt. 1454 m, on tree bark, 7 January 2014, Hur & Oh VN140075 (KoLRI).

Remarks: *Graphidastra multiformis* is close to *G. byssiseda* (Müll. Arg.) G. Thor in having spermatoid ascospores and a thallus containing roccellic acid, but *G. byssiseda* differs in producing bi-clavate larger ascospores and lacking protocetraric acid.

***Pertusaria pycnothelia*** Nyl., Bull. Soc. Linn. Norm., ser. 2, 2: 70, 1868. Pl. 1E

Thallus corticolous, crustose, greenish grey to green or pale green, shiny, ± rimose, verrucose, ≤500 µm thick in cross section, corticate; cortex 20–25 µm; photobiont *Trebouxia*, layer 85–90 µm; medulla 180–320 µm; prothallus blackish; ascomata verruciform, numerous, scattered, sometimes confluent and forming an almost continuous crust, concolorous with the thallus, flattened, hemispherical, 0.5–0.8 mm in diam; ostiole conspicuous, brown, dark brown in apothecioid to blackish in verruciform, 0.3–0.5 mm in diam; thalline margin 300–370 µm wide; proper exciple hyaline to yellowish, 25–50 µm wide; epihymenium pale brown, 45–47 µm high; hymenium hyaline, clear, 300–400 µm high; subhymenium hyaline, 80–120 µm high; paraphyses 1–2 µm thick; asci broadly clavate, 2-spored; ascospores hyaline, ellipsoid to subfusiform, double walled, wall smooth, 50–75 × 17–25 µm, I+ blue.

Chemistry: K–, KC–, C–, PD–; 4,5-dichlorolichexanthone and 2'-O-methylperlatolic acid detected in TLC.

Distribution & ecology: *Pertusaria pycnothelia* was previously reported from Australia, New Caledonia, and Papua New Guinea (Archer 1997); in Vietnam, it was collected at 1400–1500 m, where it was growing in small patches over tree bark in an evergreen forest.

Specimen examined: **VIETNAM. Lam Dong province:** Bidoup Nui Ba National Park, Đà Lạt city, 12°10′55.4″N 108°40′50.1″E, alt. 1454 m, on tree bark, 7 January 2014, Hur & Oh VN140096 (KoLRI).

Remarks: The chemically similar *Pertusaria trachyspora* A.W. Archer is distinguished from *P. pycnothelia* by ascospores with a rough inner wall.

***Pertusaria thwaitesii*** Müll. Arg., Flora 67: 470, 1884. Pl. 1F

Thallus corticolous, crustose, epiperidermal, wrinkled, cracked, uneven, shiny, off-white to pale grey, 100–150 µm thick in cross section, corticate; cortex 10–15 µm; photobiont *Trebouxia*, layer 50–80 µm; medulla white, 70–90 µm; prothallus jet black; ascomata verruciform, conspicuous, concolorous with the thallus, numerous, very flattened hemispherical or irregular in outline, 1–2 mm wide; ostioles numerous, conspicuous, pale yellow becoming black, punctiform, becoming somewhat sunken, 0.05–0.07 mm in diam., 4–7 per verruca; proper exciple hyaline to yellowish, indistinct to 30 µm wide; epihymenium indistinct; hymenium hyaline, clear, ≤430 µm high; subhymenium indistinct; asci broadly

clavate, 2-spored, 290–300 × 45–50 µm; ascospores elongate ellipsoid, double walled, inner wall ornamented and outer wall smooth, 140–165 × 35–45 µm.

Chemistry: K–, PD+ orange-red, C–; protocetraric acid detected in TLC.

Distribution & ecology: Known from Australia, Papua New Guinea, Sri Lanka (Archer 1997); in Vietnam, *Pertusaria thwaitesii* was growing in association with *Graphis* at 1700–1800 m in trees in an evergreen forest.

Specimen examined: **VIETNAM. Lam Dong province:** Mt Langbian, Đà Lạt city, 12°02′18.6″N 108°25′35.1″E, alt. 1779 m, on tree bark, 9 January 2014, Hur & Oh VN140281 (KoLRI).

Remarks: *Pertusaria hartmannii* Müll. Arg., which superficially resembles *P. thwaitesii*, differs in producing smoother ascospores and a thallus containing norstictic acid (Archer 1997).

***Phlyctis uncinata*** Stirt., J. Linn. Soc., Bot. 14: 464, 1875. Pl. 1G

Thallus corticolous, crustose, rough, epiperidermal, subleprose, ± rimose due to substrate, greenish grey, whitish green to greyish green, 100–130 µm thick in cross section, ecorticate; photobiont cells green protococcoid, layer 50–70 µm; medulla white, 40–50 µm; prothallus white; ascomata round to irregular, solitary to aggregate, immersed, 0.4–0.5 mm; disc blackish, finely pruinose, 0.2–0.3 mm in diameter; thalline margin recurved, 165–180 µm wide; proper exciple hyaline to brownish, apically dark, 35–55 µm wide; epihymenium granular, brownish 12–15 µm high; hymenium hyaline, clear, 65–80 µm high, I+ wine red; subhymenium ≤40 µm high; asci clavate, 8-spored, 110–165 × 15–25 µm, I+ wine red; ascospores hyaline, fusiform, crescent shape, transversely septate, 50–54 × 5–7 µm, 8-locular, I+ wine red.

Chemistry: K+ yellow turning red, PD+ yellow-orange, C–; norstictic acid detected in TLC.

Distribution & ecology: Known from New Zealand and Thailand (Galloway 1985, 2007); in Vietnam, the species was collected at 1700–1800 m, where it was spread in short patches on rough-barked trees.

Specimen examined: **VIETNAM. Lam Dong province:** Mt Langbian, Đà Lạt city, 12°02′18.6″N 108°25′35.1″E, alt. 1779 m, on tree bark, 9 January 2014, Hur & Oh VN140109 (KoLRI).

Remarks: *Phlyctis uncinata* is closely related to *P. karnatakana* S. Joshi & Upreti, which differs in having small (20–30 µm long) ascospores (Joshi et al. 2010). The thallus of *Phlyctis himalayensis* (Nyl.) D.D. Awasthi is morphologically similar but reacts K+ red (Awasthi 1991). *Phlyctis,* which has poorly delimited species, needs further revision to clarify the status of *P. uncinata* (Joshi & Upreti 2012; Joshi et al. 2010, 2012).

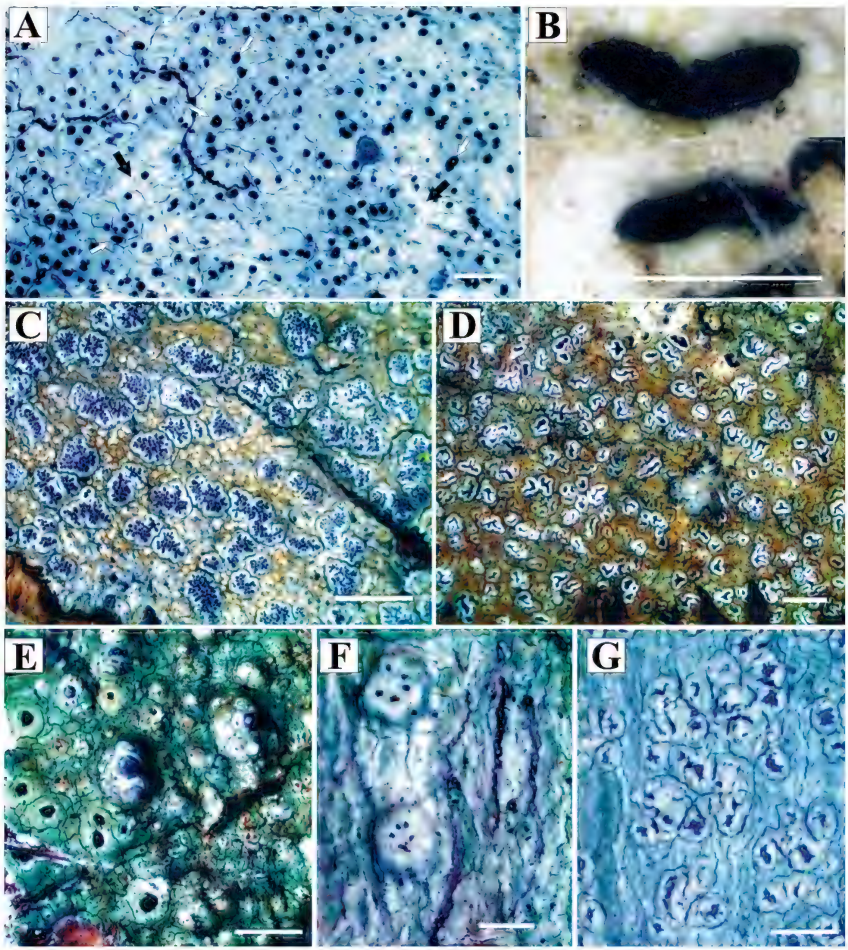


Plate. 1. New records of lichens from Vietnam. A. *Arthonia diorygmae* (white arrow indicating ascomata of *Arthonia* and black arrow indicating suppressed growth of ascomata in host); B. *Arthonia excipienda* (ascomata); C. *Chiodecton leptosporum*; D. *Graphidastra multiformis*; E. *Pertusaria pycnothelia*; F. *Pertusaria thwaitesii*; G. *Phlyctis uncinata*. Scale bars: A, F, G = 0.5 mm; B, E = 1 mm; C, D = 2 mm.

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# First records of some Asian macromycetes in Africa

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Abstract — This paper reports and discusses preliminary data on new Asian macromycete species now recorded on the African continent and collected for the first time in Niger during sampling conducted in the southwestern region from 2008 to 2012. Descriptions and comments on chorology, systematics, and closely related species are given for *Hymenagaricus subepipastus*, *Clitopilus orientalis*, *Tulostoma evanescens*, *Termitomyces bulborhizus*, and *Volvariella* cf. *sathei*.

Key words — basidiomycetes, fungi, taxonomy

## Introduction

The literature available on the macromycetes of West Africa is generally both sparse and highly fragmented. Boa (2004) reported that there appeared to be no data at all for Niger, but since then a handful of references in local publications and international journals have cited a total of 16 fully identified species for this country (Table 1). Countries bordering this sub-Saharan region (with the exception of Mali and Chad) have recently been studied by mycologists who are beginning to publish research on the diversity, systematics, ecology, ethnomycology and use of macromycetes. As a result, much more information is now available on fungal species in Benin (De Kesel et al. 2000, 2002; De Kesel & Yorou, 2000; Yorou et al. 2002a,b; Yorou & De Kesel 2002; Yorou, 2010), Burkina Faso (Ganaba et al. 2002, Guissou et al. 2002, 2008, Guissou 2005),

Table 1. Macromycete species previously recorded from Niger.

| Taxon | Reference |
|---|---|
| *Agaricus augustus* Fr. | Hama et al. 2008 |
| *Agaricus bulbillosus* Heinem. & Gooss.-Font. | Hama et al. 2008 |
| *Agaricus subsaharianus* L.A. Parra et al. | Hama et al. 2010, 2012 |
| *Crinipellis glaucospora* (Beeli) Pegler | Antonín 2013a |
| *Crinipellis pseudosplachnoides* (Henn.) Singer | Antonín 2013a |
| *Ganoderma colossus* (Fr.) C.F. Baker | Hama et al. 2008, 2009, 2012 |
| *Ganoderma lucidum* (Curtis) P. Karst. | Hama et al. 2008, 2009 |
| *Itajahya rosea* (Delile) E. Fisch. | Hama et al. 2008 |
| *Leucocoprinus brebissonii* (Godey) Locq. | Hama et al. 2008 |
| *Lyophyllum aggregatum* (Schaeff.) Kühner | Hama et al. 2008 |
| *Marasmius atrorubens* (Berk.) Mont. | Antonín 2013b |
| *Phellinus allardii* (Bres.) S. Ahmad | Hama et al. 2012 |
| *Podaxis pistillaris* (L.) Fr. | Hama et al. 2008, 2009, 2012 |
| *Termitomyces striatus* (Beeli) R. Heim | Hama et al. 2008, 2009 |
| *Trametes cingulata* Berk. | Hama et al. 2008 |
| *Trametes leonina* (Klotzsch) Imazeki | Hama et al. 2008 |

Nigeria (Zoberi 1973; Oso 1975, 1977; Adewusi et al. 1993; Osagualekhor & Okhuoya 2005; Akpaja et al. 2003; Osemwegie et al. 2006; Okhuoya et al. 2010) and, to a lesser extent, Togo (De Kesel et al. 2008, Gardt et al. 2011) and Ivory Coast (Koné et al. 2010a,b). In general, many West African ecosystems are very sparsely explored. However, Yorou et al (2014) recently updated a total list of about 72 edible macromycetes for West Africa (Benin, Burkina Faso, Ivory Coast, and Togo). In West Africa, macromycetes are not only taxonomically poorly documented, but patterns of distributions, ecology, and local use should be addressed especially in the context where forest and savannah ecosystems are disappearing at an alarming rate (FAO 2010) along with the fungal species. As an example, a preliminary Red List of threatened fungi has been published for Benin (Yorou & De Kesel 2011).

Given the lack of information regarding Niger, the University of Córdoba submitted to the Spanish Agency for International Development Cooperation a project to be implemented jointly with the Abdou Moumouni University, Niamey, entitled "Edible and cultivable Macromycetes of Niger (Ethnomycology)". One of the aims of this project was to draw up a classified inventory of Niger's fungal biodiversity. At an earlier stage, the local project team had already compiled a preliminary inventory, which was expanded and completed as part of the current research and served as a basis for the subsequent ethnomycological survey. A number of collections have been published recently (Hama et al. 2012, Antonín 2013a,b). The findings of the present study relate to the fungal diversity portion of the project and focus on the key taxonomic features of species reported earlier in Asia but which are considered first records in Africa.

## Materials & methods

Material collected between 2008 and 2012 came mainly from the West Sudanian savannah (White 1986), deemed the most suitable area for a study of national macromycete biodiversity in view of its abundant vegetation; the study centered primarily on the deep-soil, wooded savannah and gallery forests bordering rivers of the W National Park in southwestern Niger. Mushrooms were mostly collected using routine sampling methods (Halling 1996, Eyi-Ndong et al. 2011); each species was assigned a collection number and photographed with a Canon 400D, Canon PowerShot G10, or Olympus U 700 digital camera. Fresh mushroom organoleptic data – colour, odour, and taste – and information on gross features likely to be modified during drying and required for identification purposes were entered on field records. Collected mushrooms were then dehydrated in situ using a Bunsen burner attached to a folding portable dryer (De Kesel 2001) and then put inside minigrip bags. Exsiccata were kept at the Abdou Moumouni University (Niamey, Niger) and duplicates were placed in the fungal section of the COFC herbarium (Thiers 2014). Some exsiccata and type material from K and BR herbaria were requested as loans to compare with Nigerien samples and also with protologues.

Colour references were coded following Kornerup & Wanscher (1981). Material was then studied under a Nikon Labophot2 light microscope fitted with a drawing tube at a 1000× magnification. Spore measurements were made in 3% KOH mounts (Menzel-Gläser) in profile position and excluding the hilar appendix and ornamentation (Lm = mean length; Wm = mean width, Em = Lm/Wm). Unless otherwise indicated, the specimens were identified by P.P. Daniëls. Species citations follow Index Fungorum (www.indexfungorum.org). Collection localities are placed in alphabetic order. For each collection, field data are ordered as follows: Country, Administrative Region, Department, Locality, Site, {Park}, latitude/longitude coordinates, altitude, ecology and substrate, date, collector and identifier (where appropriate), collection accession number, and herbarium accession number. Distribution notes have been added when this was significant compared to other African flora, and observations are included on nomenclature and taxonomy when these differ from known species descriptions.

Standard methods for DNA extraction, PCR amplification, and DNA sequencing were applied (e.g., Justo et al. 2011) to check Nigerien *Volvariella* samples due to the noteworthy morphological differences found with closely related species. Primer pairs ITS1F and ITS4 (Gardes & Bruns 1993) were used for both PCR and sequencing. The remaining sequences used in the analysis were retrieved from GenBank and come from the studies of Menolli & Capelari (2008), Li et al. (2009), and Justo et al. (2011). GenBank accession numbers are given under the specimens examined section. *Volvariella bombycina* (Schaeff.) Singer and *V. volvacea* (Bull.) Singer were used as outgroup taxa in the final dataset. These two species appear to be the sister group to all other *Volvariella* species sequenced to date (Vizzini et al. 2011). Sequences were aligned with MAFFT (Katoh et al. 2002) using the Q-INS-i strategy. The alignment was examined and manually corrected in MacClade 4.05 (Maddison & Maddison 2002) and it has been deposited in TreeBASE (http://purl.org/phylo/treebase/phylows/study/TB2:S15058). A Maximum Likelihood analysis was run in RAxML servers (Stamatakis et al. 2008) with 100 rapid bootstrap replicates.

## Taxonomy

***Clitopilus orientalis*** T.J. Baroni & Watling, Mycotaxon 72: 58, 1999. PLATE 1

MACROCHARACTERS — BASIDIOMATA small, gregarious. PILEUS 1–2.2 cm diameter, at first convex, then flat to centrally depressed; white coloured [A1] and fibrillose; margin involute and radially ridged. STIPE central or slightly eccentric, slightly turbinate, up to 10–19 × 2–4 mm, concolourous with pileus, surface pruinose, base with white mycelial tufts. LAMELLAE subdecurrent to decurrent, with lamellulae, 3–4/mm, white at first [A1], then brownish pink [5A3, 5B5], with whitish crenulate margin. CONTEXT fibrous; odour and taste not recorded.

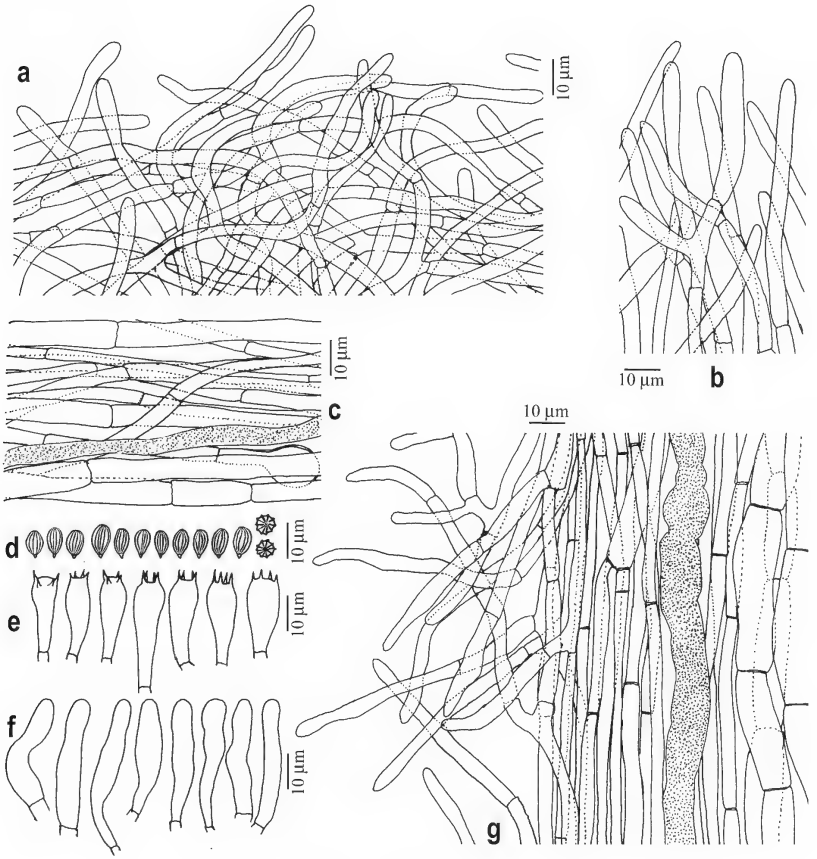


PLATE 1. *Clitopilus orientalis* (COFC-F 5160):
a) Pileipellis; b) Basal mycelium; c) Pileus context;
d) Spores; e) Basidia; f) Cheilocystidia; g) Stipitipellis showing a secretory hyphae.

Microcharacters — Pileipellis made up of interlaced 3–5 µm wide elements forming a trichodermis; hyphae hyaline, thin-walled. Stipitipellis similar to pileipellis but with inner hyphae parallel, 3–13 µm wide; hyphae hyaline, thin-walled, with conspicuous septa. Context hyphae subparallel, cylindrical, 3–8 µm wide, thin-walled, sometimes with vesicular end, 12–14 µm wide, hyaline and thick-walled. Mycelial tufts with interlaced cylindrical hyphae, 4–6.5 µm wide, hyaline, thin-walled. Secretory hyphae filled with refringent content, 5–13.5 µm wide. Clamp connections absent in all structures. Cheilocystidia cylindrical to fusiform or subcapitate, 29–37(–42) × 4–8 µm. Pleurocystidia absent. Basidia claviform, 21–30 × 7–9 µm, with 4 sterigmata, thin-walled. Spores ellipsoid, striate with 10–11 longitudinal ribs, hyaline, thin to thick-walled, (6.3–)6.8–7.5(–8.5) × (3.7–)4–4.7(–5) µm, [Lm = 7.1 µm, Wm = 4.4 µm, E = 1.40–1.88; Em = 1.63].

Specimen examined — **NIGER, Dosso**, Gaya, Albarkeizé, Saboula, 12°04′55.6″N 3°14′07.5″E, elevation 136 m, fallow land beside the Niger river on a termite mound under *Anacardium occidentale* L., 13 September 2008, O. Hama, Hama 132 (COFC-F 5160).

Ecology & Distribution — On termite mounds in India and Malaysia (Baroni & Watling 1999). *Clitopilus orientalis* appears not to have been previously reported in Africa.

Comments — This particular *Clitopilus* species displays cheilocystidia and grows on termite mounds (Baroni & Watling 1999). The specimen examined differs from descriptions of the Asian species only in that cheilocystidia are abundant and sometimes clustered, rather than scattered. The most closely related species are *C. apalus* (Berk. & Broome) Petch, which has subglobose rather than ellipsoid spores, and *C. peri* (Berk. & Broome) Petch, which neither grows on termite mounds nor displays cheilocystidia (Pegler 1977, Baroni & Watling 1999).

***Hymenagaricus subepipastus*** Heinem. & Little Flower, Bull. Jard. Bot. Nat. Belg. 54: 168, 1984. Plates 2, 3

Macrocharacters — Basidiomata small, gregarious. Pileus 0.5–1.2 cm diameter, at first convex, then trapezoid to flattened displaying dark olive-green [1E7, 30D7] scales on a light-green background [30A4], changes colour slightly during ageing, the background turns yellow [4A4] while the scales — though retaining their colour — become less abundant, since they are easily detached; margin thin, regular. Stipe central, fistulose, cylindrical, concolourous with pileus, whitish towards the base, up to 22 × 0.6 mm, surface pruinose to squamulose with scarce evanescent scales below ring zone, base

Plate 2. *Hymenagaricus subepipastus* (COFC-F 5186): Fresh basidiomata. Scale bar = 1 cm.

with white mycelial tufts. Ring absent or powdery and evanescent, seen only in very young specimens. Lamellae free, with lamellulae, 3–4/mm, greyish white at first [B2], then grayish yellow [1B2-3, 2B2-3], and finally brown [5C7], with paler crenulate margin. Spore deposit brown [5C7]. Context thin, fibrose, in stipe; odour and taste not recorded.

Microcharacters — Pileipellis made up of claviform, pyriform to spherical elements 7–17 × 7–16 µm grouped in chains and tufts forming a hymeniodermis, with thick walls and encrusted brownish orange pigments; subpellis made up of cylindrical elements, interwoven to subparallel, 3.5–8 µm, also with a thick wall and encrusted brownish orange pigments, becoming thinner, parallel and hyaline inwards. Stipitipellis formed by parallel cylindrical elements, 3–9 µm wide, often with chains of doliiform (barrel-shaped) to short-claviform terminal elements grouped in tufts; hyphae hyaline to yellowish brown, thin- to thick-walled, somewhat constricted at the septa. Context hyphae subparallel, cylindrical, 4–12 µm wide, thin-walled. Mycelial tufts with parallel cylindrical hyphae of 2–3.5(–5) µm wide, hyaline and thin-walled, sometimes with secretory hyphae, filled with refringent contents. Clamp connections absent in all structures. Cheilocystidia lageniform to fusiform, 16–20(–26) × (5–)6–10(–12) µm. Pleurocystidia absent. Basidia widely claviform, 12–15 × 5–7 µm, with (2)4 sterigmata, thin-walled. Spores ovoid to ellipsoid, smooth, brown coloured, thin to

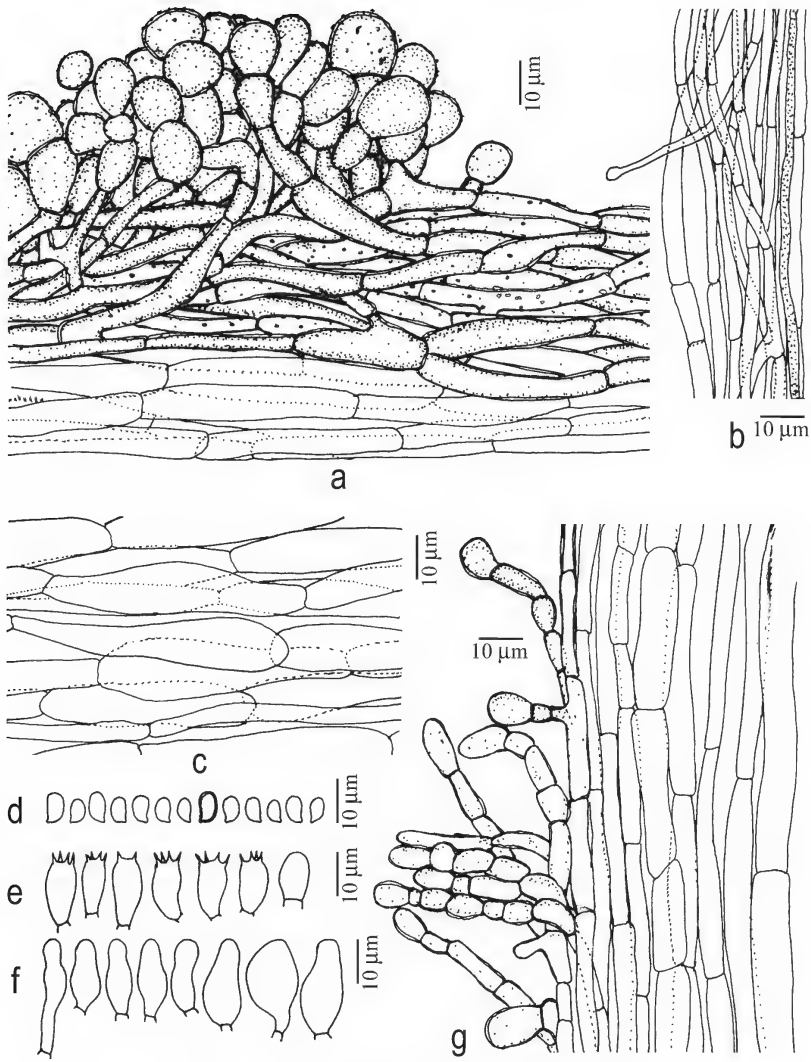


Plate 3. *Hymenagaricus subepipastus* (COFC-F 5186):
a) Pileipellis; b) Basal mycelium; c) Pileus context; d) Spores;
e) Basidia; f) Cheilocystidia; g) Stipitipellis.

thick-walled, (4–)4.5–6.3 × (2.7–)3–4(–4.5) µm, [Lm = 5.1 µm, Wm = 3.4 µm, E = 1.29–1.71; Em = 1.49].

Specimen examined — **NIGER, Niamey**, Niamey, Karadjé, guest house at Abdou Moumouni University, 13°29′25.5″N 2°04′64″E, elevation 200 m, in garden soil, 8 August 2010, P. Daniëls, Hama 383 (COFC-F 5186).

Ecology & Distribution — Scattered in the grass or garden soils. *Hymenagaricus subepipastus* was first described in India (Heinemann & Little Flower 1984), but Heinemann (1986) considered its presence in Africa likely. Our report may be the first record of the species in Africa.

Comments — Our specimen fully matches existing descriptions of *H. subepipastus* by Heinemann & Little Flower (1984). This species is related to *H. viridulus* Heinem. & Little Flower, but the spores of the studied collection are larger and ovoid rather than cymbiform (wineskin-shaped). *Hymenagaricus subaeruginosus* (Berk. & Broome) Heinem. & Little Flower has slightly smaller, cymbiform spores and larger basidiomata, with a pileus up to 4.5 cm diameter (Heinemann & Little Flower 1984). *Hymenagaricus epipastus* (Berk. & Broome) Heinem. & Little Flower differs from *H. subepipastus* only in spore size, and has been reported in Ceylon (Asia) (Heinemann & Little Flower 1984). For details see Table 2.

Table 2. Comparison of pileus and spores from species related to *Hymenagaricus subepipastus*.

| Species | Pileus diam. (cm) | Lm | Wm | Spore shape |
|---|---|---|---|---|
| *H. viridulus* type [a] | 0.5–1.5 | 4.7 | 3.3 | Cymbiform |
| *H. subaeruginosus* isotype (K) | 1.5–2.5 [b] / 4.5 | 4.7 | 3.2 | Cymbiform |
| *H. subaeruginosus* MGF 5088 (BR) | 1.5–2.5 [b] | 4.5 | 3.0 | Cymbiform |
| *H. epipastus* type [a] | 2 | 4.2 | 3.1 | Ovoid |
| *H. subepipastus* type [a] | 1–1.5 | 5.0 | 3.6 | Ovoid |
| *H. subepipastus* Hama 383 | 0.5–1.2 | 5.1 | 3.4 | Ovoid |

[a] Heinemann & Little Flower 1984; [b] measurements in exsiccatum

***Termitomyces bulborhizus*** T.Z. Wei, Y.J. Yao, B. Wang & Pegler, Mycol. Res. 108: 1458, 2004. Plates 4–6

Macrocharacters — Basidiomata medium sized, gregarious. Pileus 4–12 cm diameter, fleshy, at first convex, then flattened and slightly depressed with obtuse blunt perforatorium 2–3 mm wide; white, isabella to olivaceous brown coloured [A1, 4A4, 4B6, 5A3] pallescent towards the margin and with brownish orange centre [6D5, 5B6-8]; surface smooth and dry or slightly viscose and radially rugose in wet conditions; margin thin, sinuous to sub-lobate, slightly involute when young then uplifted when old. Stipe central, cylindrical, straight, white to slightly isabella coloured [A1], (4–)7–11 × 0.5–2 cm, surface squamulose with evanescent recurved 2–3 mm long scales; bulbose at ground level of 2–3.5 cm diameter. Pseudorhizoid robust, rugose and grooved longitudinally, orange brown [4B5, 5C5, 6C8, 6B7] to black [5E3, 6F2-5, F1] downwards, of 5–20 cm long, tapering quickly towards the base. Lamellae

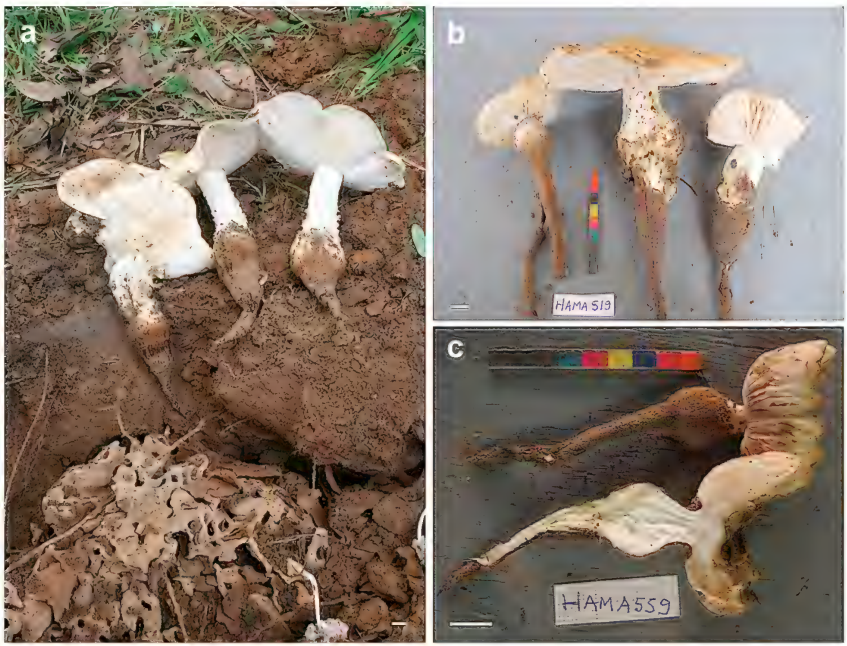


Plate 4. *Termitomyces bulborhizus*: fresh basidiomata:
a) COFC-F-5301; b) COFC-F-5305; c) COFC-F-5306. Scale bar = 1 cm.

free to almost free, with lamellulae, crowded, 8–12/cm, to 6 mm wide, white to slightly pink [A1, 6A2] with concolourous margin; spore deposit pink [6A2]. Context solid, fibrous, ≤1 cm in pileus; odour sometimes of fresh fish (taste not recorded). Termite mold ellipsoid, 10–20 cm long, grayish isabelline [4A5, 5C2] with irregular 0.5–1.5 cm wide holes.

Macrochemical reactions — KOH– in pileus; HCl+ dark yellow in pileus.

Microcharacters — Pileipellis made up of doliiform to cylindrical elements 6–17 × 3–9 μm, hyaline with thin wall, somewhat constricted at the septa; hyphal width increasing through context; parallel to interwoven forming a lax ixocutis-subtrichodermis. Pseudorhizoid formed by parallel cylindrical to doliiform elements, 4–15 μm wide in the external zone with often claviform to cylindrical terminal elements; hyphal width increasing through context to 15–35 μm wide, hyphae brown with thick wall, constricted at the septa. Stipitipellis similar to pseudorhizoid but hyphae hyaline, 3–5 μm wide in the external zone and 7–18 μm wide through context. Context hyphae cylindrical, 9–21 μm wide with thick 0.5–2 μm wall, and mixed with cylindrical hyphae 4–7 μm wide, with thin wall. Clamp connections absent

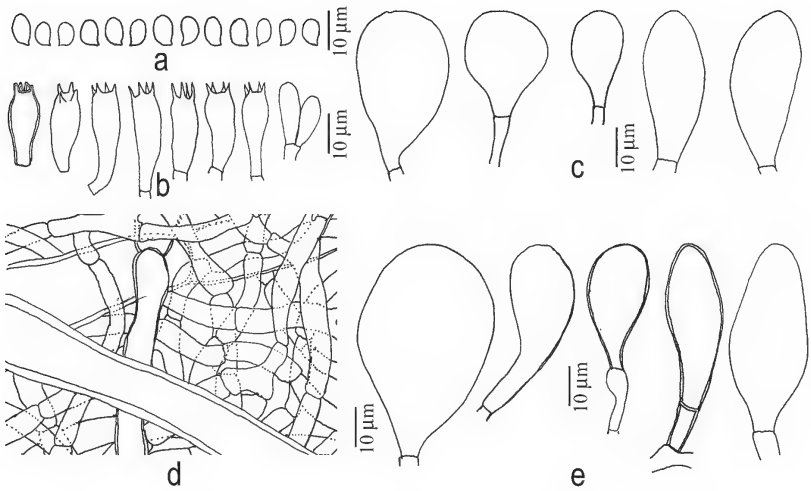


Plate 5. *Termitomyces bulborhizus* (COFC-F 5306):
a) Spores; b) Basidia; c) Cheilocystidia;
d) Pileus context; e) Pleurocystidia.

in all structures. Cheilocystidia claviform, fusiform to pyriform, (25–)27–42 × (11–)13–24 µm. Pleurocystidia similar, sometimes with a secondary septum and/or thick wall, 28–56 × (10–)11–20(–35) µm. Basidia claviform, 18–24(–27) × 6–8.5 µm, with (2–)4 sterigmata and thin to, rarely, thick-walled. Spores ellipsoid, smooth, hyaline, thin-walled, (5.5–)6–7(–8) × (3–)3.8–4.4(–5) µm, [Lm = 6.4 µm, Wm = 4.1 µm, E = (1.38–)1.50–1.75(–1.80); Em = 1.56].

Specimens examined — **NIGER, Dosso**, Gaya, Gaya, Gorou Bassounga Forest, 11°54′00″N 3°24′25″E, elevation 209 m, savannah, on termite nest, 5 September 2010, O. Hama, Hama 443b (COFC-F 5302). **Tillabery**, Say, Tamou, Haoussa, 12°15′18″N 2°22′14″E, elevation 221 m, wooded *Afzelia africana* Smith ex Pers. savannah, on underground termite nest, 6 August 2010, O. Hama, Hama 286 (COFC-F 5301); 12°14′50″N 2°22′14″E, 24 August 2011, O. Hama, Hama 470 (COFC-F 5303); 25 August 2011, O. Hama, Hama 475 (COFC-F 5304); 12°14′51″N 2°22′15″E, wooded savannah of *Afzelia africana*, *Combretum glutinosum* Perr. ex DC., *C. collinum* Fres., with *Andropogon gayanus* Kunth, *Crossopteryx febrifuga* (Afzel. ex G. Don) Benth., *Strychnos spinosa* Lam., and *Flueggea virosa* (Willd.) Royle, on active termite nest, 15 August 2012, O. Hama, Hama 519 (COFC-F 5305); Say, Torodi, Gnaktiré, 12°59′01″N 1°44′32″E, elevation 237 m, cropland, under *Sclerocarya birrea* (A. Rich.) Hochst., on termite mound, 25 August 2010, O. Hama, Hama 405 (COFC-F 5095); 12°59′09.4″N 1°44′08.5″E, elevation 226 m, in a field of *Pennisetum glaucum* (L.) R. Br. and *Sorghum bicolor* (L.) Moench, close to *Balanites aegyptiaca* (L.) Delile, on a termite nest, 19 August 2012, O. Hama, Hama 559 (COFC-F 5306).

Ecology & Distribution — This taxon has been reported growing on termite nests in southern China (Sichuan, Yunnan) and Thailand (Wei et al.

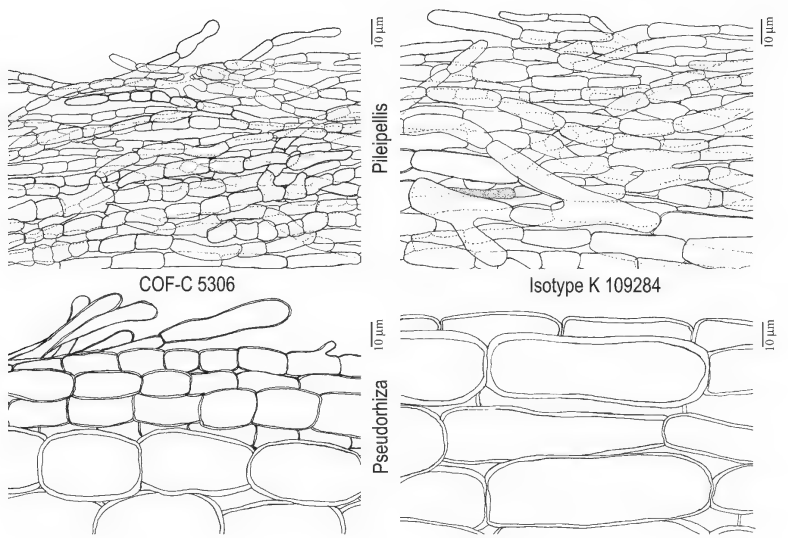


Plate 6. *Termitomyces bulborhizus*: comparison of pseudorhizoid and pileipellis from exsiccata COFC-F 5306 (left) and isotype K 109284 (right).

2004; Sawhasan et al. 2011). The associated termite species is identified as *Macrotermes barneyi* Light, native to Vietnam and southern China (Wang et al. 2009) and *Hypotermes makhamensis* Ahmad in the Thailand collection (Sawhasan et al. 2011). In this first African finding, the associated termite was *Macrotermes subhyalinus* (Rambur) (Koné, pers. comm.).

Comments — *Termitomyces bulborhizus* is a large mushroom with a characteristic black, swollen pseudorhizoid; the stipe surface appears slightly scaly due to the presence of fine floccules.

Our material differs slightly from the isotype of *T. bulborhizus* (K 109284) in the pileipellis structure that can be justified to different development stages of the fruitbodies. Due to the few notes regarding pileipellis and pseudorhizoid structure of this species, we consider showing them from both isotype and COFC-F 5306 (Plate 6). Descriptions of referred structures in the isotype are as follows: pileipellis made up of doliiform to cylindrical elements 8–45(–78) × 4–17 µm, hyaline with thin wall, somewhat constricted at the septa; hyphal width increasing through context; parallel to interwoven forming a subtrichodermis cutis; pseudorhizoid formed by parallel cylindrical to doliiform elements, 15–32 µm wide, hyphae brown with thick wall, constricted at the septa. The pseudorhizoid of the isotype was not clean enough for an accurate analysis so

we do not know enough to ascertain whether it might also have small hairs or claviform caulocystidia-like structures, as in the Nigerien sample. The bulbose stipe width in Nigerien samples was also smaller (<3.5 cm wide) than those given by Wei et al. (2004). Actually, Asian collections are bigger than African ones regarding basidioma size, with a pileus of (5–)10–22 cm (Wei et al. 2004).

Our material differs from *T. eurrhizus* (Berk.) R. Heim in having a dark-brown color and a swollen pseudorhizoid (Wei et al. 2004). In the most similar African species (*T. umkowaan* (Cooke & Massee) D.A. Reid and *T. subumkowaan* Mossebo) the stipe surface is smooth and the pseudorhizoid is not swollen. Also, *T. subumkowaan* bears two spores per basidium (Mossebo et al. 2002).

Plate 7. *Tulostoma evanescens* (COFC-F 5292): Exsiccatum. Scale bar = 1 cm.

***Tulostoma evanescens*** Long & S. Ahmad, Farlowia 3: 235, 1947. Plates 7, 8

Macrocharacters — Basidiomata small, gregarious. Globose head 0.7–0.9 cm diameter. Exoperidium undefined, hyphal, thin, brown [5B4], intermixed with sand grains. Endoperidium membranous, smooth, white [A1]. Peristome circular and not prominent, white [A1] because of the absence of exoperidium around the mouth. Stipe cylindrical or tapering upwards, 1–1.3 × 0.2–0.3 cm, surface squamose with evanescent scales and longitudinally grooved, joined in the base to form a volva-like swollen structure in one basidioma; sometimes with rhizomorphs. Socket lacerate, with several small dentate membranes around the stipe. Gleba brown coloured [6C6]. Context firm, fibrous; odour absent and taste not recorded.

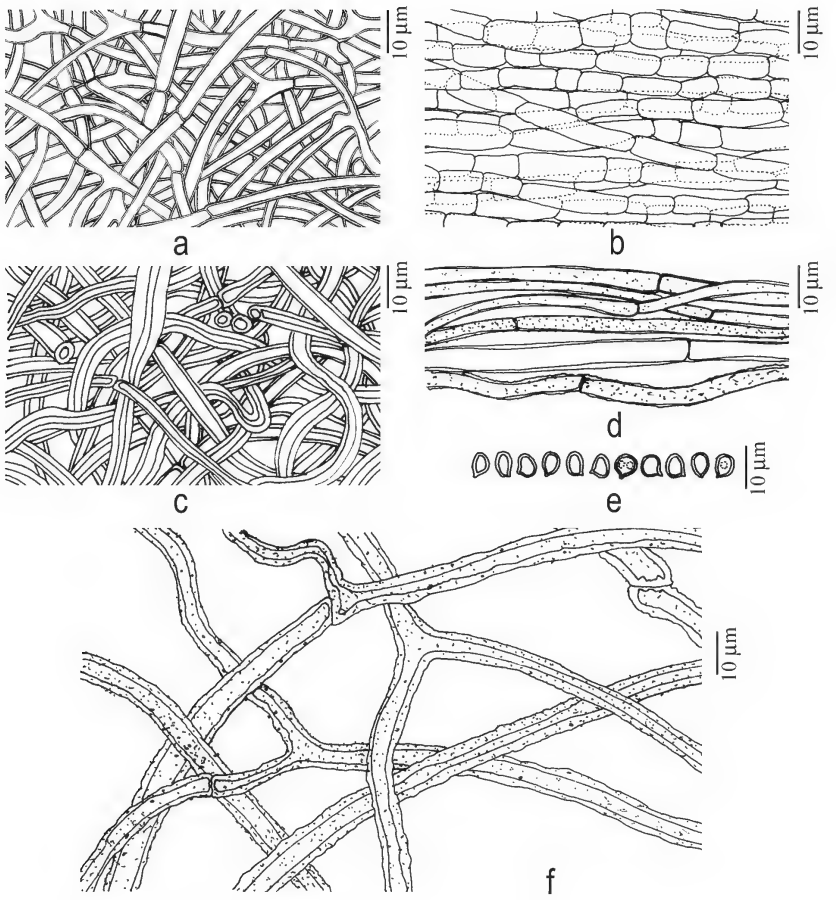


Plate 8. *Tulostoma evanescens* (COFC-F 5292):
a) Exoperidium; b) Context of stipe scales; c) Endoperidium;
d) Hyphae of rhizomorph; e) Spores; f) Capillitium.

Microcharacters — Exoperidium with cylindrical interlaced hyphae, 1.5–4 µm wide with, hyaline to brownish, moderate wall. Endoperidium similar, with hyphae 3–6(–8) µm wide, hyaline and with thick wall. Capillitium 3–8 µm wide, with lumen and thick wall minutely encrusted with granules, septate and with a few branches. Hyphae of stipe scales parallel, 4–6.5 µm wide, grouped in tufts; hyphae hyaline to yellowish, with thin wall, somewhat constricted at the septa. Hyphae of rhizomorph 2.5–7 µm wide, hyaline, often minutely encrusted with granules and with moderate wall.

Clamp connections absent in all structures. Basidia not seen. Spores ovoid to ellipsoid, smooth, brown coloured, thick-walled, some apiculate, (4.7–)5–5.4(–6) × (3.7–)4–4.5(–5) µm, [Lm = 5.2 µm, Wm = 4.1 µm, E = 1.11–1.38; Em = 1.26].

Specimen examined — **NIGER, Tillabery**, Say, Tamou, Tamou Total Faunal Reserve {Tamou Reserve}, 12°34′21″N 2°18′28″E, elevation 240 m, wooded savannah, humus-containing sandy soil, 7 August 2010, O. Hama, Hama 361 (COFC-F 5292).

Ecology & Distribution — This species grows in arid sites and appears after rains in copious quantities. According to Wright (1987), this species has been reported in India and Argentina. This appears to be the first report of this species in Africa.

Comments — The material examined here agrees with earlier descriptions, including the following features: 1) Clearly-defined circular, tubular, or flat peristome on a head of ≤1 cm in diameter; 2) smooth subglobose or ellipsoid spores measuring about 5–5.4 × 4–4.5 µm; 3) inconspicuous hyphal exoperidium; and 4) capillitium 4–10 µm wide.

*Tulostoma operculatum* Long & S. Ahmad has smaller (4–4.7 µm diam.) spores and a fimbriate mouth. *Tulostoma brevistipitatum* B. Liu et al. does not have a volvoid structure at the stipe base, and its spores are slightly longer (5.4–6.1 × 4.3–5 µm). *Tulostoma fusipes* Har. & Pat. is very similar, but its spores are globose, the capillitium is coloured, and the stipe is longer (5.5 × 0.4 cm) (Wright 1987).

***Volvariella* cf. *sathei*** Senthil., Rahul Sharma & S.K. Singh, Mycotaxon 119: 470, 2012. Plates 9, 10

Macrocharacters — Basidiomata medium sized, gregarious. Pileus 3.5–12(–15) cm diameter, fleshy, convex; white to isabella [A1, 4A2]; surface fibrillose; margin exceeding the lamellae, eroded, or striate with triangular tufts. Stipe central, fistulose when aged, cylindrical and tapering towards apex, straight, concolourous with pileus, 5–12 × 1–2 cm, surface glabrous to fibrillose; slightly bulbose. Volva membranous, 1–5 × 2–4 cm and 1–1.5 mm thick, white [A1], sometimes with grayish brown hue [4C3]. Lamellae free, distant from stipe, with lamellulae, crowded, (10–)13–16(–17)/cm, 3–5 mm wide, at first whitish [A1, 3A2] then pink [9A2, 14A3] with paler, dentate to fibrillose margin. Spore deposit pink [9A3, 10B5]. Context solid, fibrous; odour disagreeable, farinaceous to fruity, and pleasant taste.

Macrochemical reactions — KOH– or NaOH– in pileus, context or stipe.

Microcharacters —Pileipellis made up of cylindrical elements 8–21 µm, hyaline with thin to thick wall, somewhat constricted at the septa; parallel, forming a regular cutis. Stipitipellis similar to pileipellis, hyphae

Plate 9. *Volvariella* cf. *sathei*, fresh basidiomata:
a) COFC-F-5092; b) COFC-F-5036; c) COFC-F-5033. Scale bar = 3 cm.

hyaline, 4–15 µm wide in the external zone and up to 35 µm wide through context. Context hyphae cylindrical, 8–21(–28) µm wide with thin wall. Volva composed mostly of cylindrical hyphae, 3–5 um wide with scattered inflated elements, cylindrical, fusiform or irregularly shaped, up to 20 um wide. Basal tomentum formed by interlaced cylindrical elements, 5–22 µm wide; hyaline with thin to thick wall. Clamp connections absent in all structures. Cheilocystidia fusiform to lageniform, 40–88(–95) × 10–38 µm, with hyaline thin wall, sometimes with a basal secondary septum. Pleurocystidia similar, 39–80 × 11–24 µm. Subhymenium cellular, with ellipsoid to doliiform hyphae, 10–20 µm in diameter. Basidia claviform, (19–)22–27(–30) × 7–9 µm, with (2–)4 sterigmata and thin-walled. Spores globose to ob-triangular, smooth, brownish pink, thick-walled, (5–)5.6–6(–7) × (4.5–)5.1–5.7(–6.7) µm, [Lm = 5.8 µm, Wm = 5.4 µm, E = 0.92–1.40; Em = 1.07].

Specimens examined: **NIGER**, **Niamey**, Niamey, Abdou Moumouni University, Faculty of Agricultural Sciences, experimental garden, 13°30′00.5″N 2°05′24.5″E, elevation 178 m, in a disturbed area, growing on plant residue under *Prosopis juliflora* (Sw.) DC., 6 August 2009, O. Hama, det. A. Justo, Hama 175 (COFC-F 5036); sandy

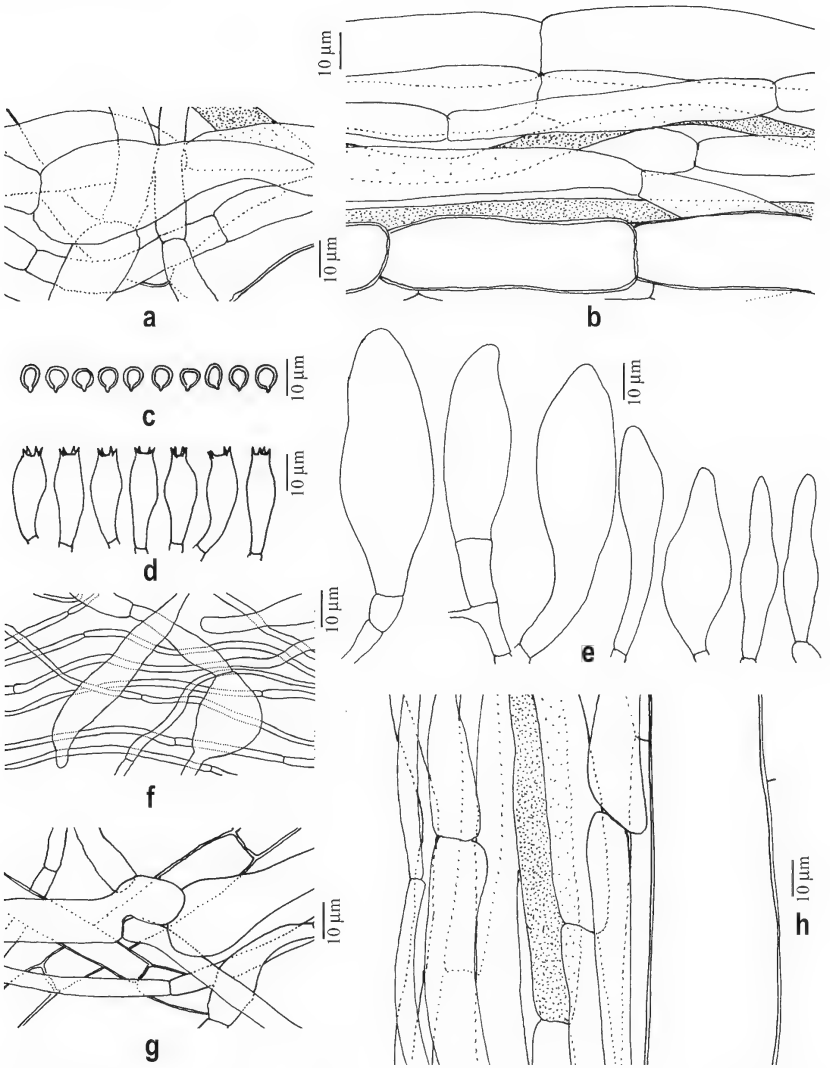


Plate 10. *Volvariella* cf. *sathei* (Figs a–e, g–h from COFC-F 5448; Fig. f from COFC-F 5033): a) Pileus context; b) Pileipellis; c) Spores; d) Basidia; e) Cheilocystidia; f) Volva, g) Basal tomentum, h) Stipitipellis.

soil with cattle manure under *Prosopis juliflora*, O. Hama, Hama 176 (COFC-F 5092); Niamey, Abdou Moumouni University, High School of Education, 13°30′07″N 2°05′29″E, elevation 187 m, in a disturbed area, in sandy soil near *Azadirachta indica* A. Juss., 4 August 2010, O. Hama, det. A. Justo, Hama 390 (COFC-F 5088; Genbank KF926666). **Tillabery**, Say, Torodi, Fayra, 13°01′26.7″N 1°45′39.4″E, elevation 232 m, in arable fields with plant residue of *Piliostigma reticulatum* (DC.) Hochst., 21 August

2008, O. Hama, Hama 38 (COFC-F 5448); Say, Torodi, Gnaktiré, 12°59′02″N 1°44′49″E, elevation 222 m, cropland, growing on organic residue near houses with *Pennisetum glaucum* and *Sorghum bicolor*, 16 August 2009, O. Hama, det. A. Justo, Hama 194 (COFC-F 5034; Genbank KF926664); 12°59′01″N 1°44′32″E, elevation 221 m, in arable fields on heaped-up plant residue with *Sorghum* and *Pennisetum*, 15 August 2009, O. Hama, det. A. Justo, Hama 193 (COFC-F 5035; Genbank KF926663); Say, Tamou, Mékrou, {W National Park}, 12°15′16″N 2°23′24″E, elevation 218 m, in gallery forests with *Cola laurifolia* Mast., *Diospyros mespiliformis* Hochst. ex A. DC., *Mitragyna inermis* (Willd.) Kuntze, on sandy-clay soils, 22 August 2009, O. Hama, Hama 204, det. A. Justo (COFC-F 5033; Genbank KF926665).

Ecology & Distribution — The authentic species, *Volvariella sathei*, was recently proposed, based on Indian material (Senthilarasu et al. 2012), and has not been reported elsewhere.

Comments — The large white species, *V. sathei*, differs from *V. nivea* T.H. Li & Xiang L. Chen in having ovoid to widely ellipsoid spores and larger cystidia (Senthilarasu et al. 2012).

Our samples agree mostly with the description given by Senthilarasu et al. (2012) except for: (1) the presence of fusiform to lageniform cystidia (cylindro-clavate in *V. sathei*); (2) spores often with a triangular shape; and (3) grayish hue sometimes present in volva. Molecular analysis indicates that the African isolates are in the same clade as the Indian *V. sathei* but that there are some differences between them (Plate 11). Additional data are needed to confirm whether the African isolates represent *V. sathei* or a closely related taxon.

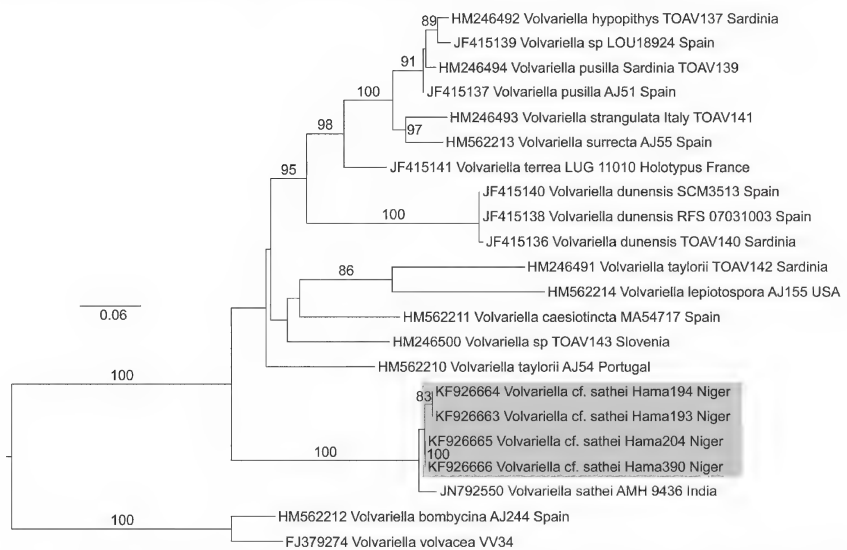


Plate 11. Best tree from the Maximum Likelihood analysis of ITS sequences of *Volvariella*. Nigerien samples of *V.* cf. *sathei* are emphasized. Scale bar indicates nucleotide substitutions/site.

## Discussion

The taxa examined here are species previously recorded in Asia; this is the first time they have been reported on the African continent. Fungal species common to both continents are frequently reported, perhaps due to climatic and/or ecological similarities, spore dispersal capacity, and shared geological history; cases of vicariance and species fragmentation are also found (Berndt 2002, O'Donnell et al. 2011, Geml et al. 2008, Moncalvo & Buchanan 2008). The fragmentation of biogeographical ranges may sometimes be due to human intervention and particularly to the introduction of exotic plant species with their own associated fungal suites (Niveiro et al. 2009, Chen et al. 2006, Read 2000, Pringle et al. 2009); some ectomycorrhizal fungi entered Africa by this means (Duponnois & Galiana 2007, Garbaye et al. 1988). The climate of the West Sudanian savannah is similar to that of the Asian savannah of India, Laos, Thailand, Myanmar, Vietnam, and Cambodia (Young & Solbrig 1993). There are, however, differences in floral composition, with *Dipterocarpaceae* predominating in Asia and *Leguminosae* in Africa. This can help to discriminate some tree-restricted ectomycorrhizal species better than saprobes. However, there are some wide-ranging mycorrhizal fungi, which could also suggest a lack of fungal sampling in this ecosystem type (*Tulostoma evanescens* might represent such a case). Actually, infrequent sampling of the African savannah may have led to a bias in our knowledge of the biogeographical range, substrate versatility, spore dispersal capacity, and ecological similarity of these species. Furthermore, some saprobic species are often unspecific regarding substrate degradation and sometimes the substrate itself is originated by fire or domestic herbivore digestion, reducing substrate differences between distant geographic areas.

Mushrooms associated with termite nests grow only where termites are found. Several termite genera and species (e.g. *Macrotermes*, *Microtermes*, and *Odontotermes*) are common to both continents (Cheng and al. 2011) and this kind of mycological association seems to have originated in West Africa (Nobré et al. 2011). *Clitopilus orientalis* is a saprobic fungus with an apparent preference for termite nests.

Our discoveries provide a promising basis for further research into Niger's fungal diversity. Many collections are yet to be reviewed, and their examination will doubtless enhance our knowledge of fungal diversity in the West Sudanian savannah as a whole, and also enable a closer appraisal of its similarity with its Asian counterpart. More samples and DNA-analysis of the studied material are needed to discern cryptic species, and *Volvariella* cf. *sathei* may be a geographic variety of the Asian species.

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# Contribution to the knowledge of *Inonotus baumii* in Thailand

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Abstract —*Inonotus baumii* in Thailand is reported on three new host-plants: *Acacia tomentosa*, *Shorea robusta*, and *S. siamensis*. A key for the identification of *Inonotus* species in Thailand accompanies notes on the taxonomy of *I. baumii*.

Key words — *Basidiomycota*, *Hymenochaetales*, *Phellinus*, white rot fungus

## Introduction

Fungi are one of the most species-rich groups of organisms but compared to plants they are still vastly under-investigated (Hawksworth 1997). In particular there is still a lack of distribution and ecological data on several fungal species (Venturella et al. 2011). This is even more true for wood-inhabiting fungi, which have become increasingly important in recent years not only for their ecological role but also as natural sources of anticancer, antioxidative, and antibacterial agents (Karaman et al. 2010).

Several wood-decaying species are used in Asian folk medicine (Larsson et al. 2006). An example is *Inonotus baumii*, sometimes erroneously named *Phellinus linteus* (Berk. & M.A. Curtis) Teng, which is known for its use in traditional Chinese medicine (Ying et al. 1987, Shon et al. 2003). Larsson et al. (2006) have researched the perplexing taxonomy of *Hymenochaetales*, while Tura et al. (2011) have conducted cultural-morphological investigations on

*I. baumii* [sub *Phellinus baumii*] and *P. linteus*. According to these authors, the taxonomic delimitation at the generic and species level in *Phellinus* s.l. and *Inonotus* s.l. is confusing, and *P. linteus* and *I. baumii* [sub *P. baumii*] show close phylogenetic relationships within the *P. linteus* species complex.

Wu et al. (2012) investigated the species delimitation of the *I. baumii–I. linteus* group (including taxa recorded as *P. linteus*) and included the "sanguangh mushroom," a popular polypore used medicinally in China, Japan, and Korea. They described the "sanguangh mushroom" as a new species (*Inonotus sanghuang* Sheng H. Wu et al.) growing solely on *Morus* sp. in China, Japan, Korea, and Taiwan. Wu et al. (2012) also reported *I. baumii* on living *Syringa* sp. distributed in temperate NE Asia. Parmasto & Parmasto (2001) highlighted the need for correctly identifying the host species when collecting *Phellinus* species on trees or bushes in tropical and subtropical areas. The effects of Cambodian *P. linteus* in the wood chemistry and structure of *Shorea obtusa* Wall. ex Blume were investigated by Srivilai et al. (2013).

The aim of this paper is to contribute to the knowledge of *Inonotus baumii* in Thailand and to report three new host plants.

## Materials & methods

The studied basidiomata were collected in different periods of the year in Chiangmai (Mai Hongson Province) and the northeastern region of Thailand; the morphological characters of basidiomata kept in the personal collection of one of the authors (A. Auetragul) were also examined. The morphology of fresh and dried basidiomata was analyzed in the Laboratory of Mycology of the Department of Agricultural and Forest Sciences (University of Palermo, Italy). The basidiospore length and width, mean number of pores per mm, mean size of setae, and diameter of tramal skeletal hyphae were determined according to Parmasto & Parmasto (2001). Morphological characters were also evaluated according to the identification keys of Wu et al. (2012) and Tian et al. (2013), which consider the hymenial surface pore sizes, basidiospore length and width, basidioma type, pileus surface characters, color of the pileal surface marginal zone, and host-plants. The host-plants on which we collected the basidiomata were identified according to Graf (1992). Fungal nomenclature follows MycoBank. The dried herbarium specimens are kept in the collection of AnonBiotec Institute, Department of Biotech, The North Chiangmai University, Thailand (DBNC) and the Herbarium, Department of Agricultural and Forest Sciences, University of Palermo, Italy (SAF).

## Taxonomy

***Inonotus baumii*** (Pilát) T. Wagner & M. Fisch., Mycologia 94: 1009 (2002) PLATE 1

Basidiomata woody, perennial, sessile, semicircular, ungulate or imbricate, 7 × 15 cm, 5–6 cm thick at the base, pileal surface dark grayish brown to dark gray, densely sulcate, radially rimose and cracking; margin rounded; hymenophores golden yellow when unripe then dark brown with wide and

Plate 1. *Inonotus baumii* basidiomata (photos courtesy of AnonBiotec).
A, from *Shorea robusta* (DBNC 021, SAF 038); B. from *Acacia tomentosa* (DBNC 020).

sterile zone along the margin; pores regular, circular 8–10 per mm; tube layers receding in old basidiomata; context woody. Hyphal system dimitic; generative hyphae simple-septate, hyaline to golden yellow, 2–2.5 µm wide; skeletal hyphae golden yellow to golden ferrugineous, thick-walled, up to 4–5 µm wide; hymenial setae frequent to scanty, ventricose with an acute apex, thick-walled at the base, 20–27 × 5–13 µm; basidia clavate, 7–12 × 5–8 µm, tetrasporic; basidiospores broadly ellipsoid to subglobose, hyaline then pale yellowish brown, thin-walled, 6 × 5 µm.

Specimens examined: **THAILAND. Northern Thailand:** Chiang Mai Province, Chiang Mai, UTM 2077469 498244 47Q, 310 m, on living and dead trees of *Acacia tomentosa* Willd. (*Leguminosae*), 20 Oct 2012, A. Auetragul (DBNC 020); Mae Hong Son Province, Mae Hong Son, UTM 2134467 391785 47Q, 240 m, on living and dead trees of *Shorea robusta* C.F. Gaertn. (*Dipterocarpaceae*), 17 Oct 2013, A. Auetragul (DBNC 021, SAF 038); Lampang Province, Lampang, UTM 552842 2023449 47Q, 244 m, on living and dead trees of *Shorea siamensis* Miq. (*Dipterocarpaceae*), 25 Oct 2013, A. Auetragul (DBNC 022).

## Identification key for *Inonotus* spp. in Thailand

(partly modified from Wu et al. 2012)

1. Pores of hymenial surface <5/mm ..... ***I. lonicerinus***
1. Pores of hymenial surface >5/mm ..... 2
2. On dead branch of *Lonicera* spp. Basidiospores mostly <4. 1 × 3.1 µm ***I. lonicericola***
2. Not on *Lonicera* spp. Basidiospores mostly >4.1 × 3.1 µm ..... 3
3. On fallen trunks of *Populus* spp. Basidiomata resupinate or pileate. Pileus surface indistinctly or moderately sulcate with furrows <3/cm. Pileus always with a wide yellow marginal zone on the surface ..... ***I. vaninii***
3. Not on *Populus* spp. Basidiomata pileate. Pileus surface densely sulcate with furrows >3/cm. Pileus usually lacking a wide yellow marginal zone on the surface in ripe basidiomata .....4

4. On *Weigela coraeensis*. Basidiomata sessile to effused-reflexed. Pileus applanate, frequently becoming decurrent with more or less effused base, surface with a thin and black crust, margin usually thin and acute ..... ***I. weigelae***
4. Not on *Weigela*. Basidiomata always sessile. Pileus applanate to concave or subungulate; surface without a thin crust. Pileus surface sometimes black and crustose in ripe basidiomata. Pileus margin acute or blunt .....5
5. On *Morus* spp. Basidiomata perennial, sessile, pileate. Pileus applanate or applanate with an umbo to convex, adaxially flat, slightly convex or slightly concave. Pore surface golden-yellow, brownish yellow to yellowish brown. Pileus margin turning dark-red with KOH ..... ***I. sanghuang***
5. On dead and living trees of *Syringa* sp., *Acacia tomentosa*, *Shorea robusta, S. siamensis*. Basidiomata always sessile, applanate to subungulate, adaxially more or less concave, margin acute or blunt, thin crust absent, although pileus surface may become black and crustose in ripe basidiomata, surface densely sulcate, with farrows >3/cm. Aged pileus usually lacking a wide yellow marginal zone on pileus surface. Pileus margin not turning dark-red with KOH. Pore surface yellowish brown. Pores of hymenial surface >5/mm. Basidiospores more or less sphaerical, 6 µm long and 5 µm wide ..... ***I. baumii***

*Inonotus baumii* (*Hymenochaetaceae*) belongs to the *I. baumii–I. linteus* group distributed in temperate NE Asia. It has been recorded on living and dead trees of *Syringa* (Wu et al. 2012) in China (Dai 2010), Japan (Ito 1955), Korea (Lim et al. 2003), and Far East Russia (Parmasto & Parmasto 2001). *Phellinus linteus* has been reported to grow on *Quercus* L., *Cassia* L., *Lonicera* L., *Morus* L., *Symplocos* Jacq., and *Hemiptelea* Planch. (Ahmad 1972, Kang et al. 2002, Larsen & Cobb-Poulle 1990, Lim et al. 2003). However, Lim et al. (2003), who investigated basidiomata from China, Korea, Costa Rica and, Mexico, showed that the temperate East Asian species known as "*P. linteus*" represents *I. baumii*. Wu et al. (2012) proved that specimens collected on *Morus* species represent another taxon, *I. sanghuang*.

## Discussion

The difficulties in identifying *Inonotus* and *Phellinus* spp. belonging to the *P. linteus* species complex fuel a wide debate on the taxonomic status of the collected basidiomata growing on different wild and ornamental trees. This is also due to the great interest by scientists and people towards the medicinal use of the mushrooms identified as *P. linteus* and/or *I. baumii*. The worldwide scientific movement on medicinal mushrooms and the mushroom industry (mainly in Asian countries) specifically requires an exact identification of mushroom species (Wasser 2013). According to our investigation the host range of the *P. linteus* species complex is not exhaustive. We report *Inonotus baumii* for the first time on three new host plants growing in Thailand: *Acacia tomentosa* (Plate 2), *Shorea robusta* (Plate 2), and *S. siamensis* (Plate 3).

PLATE 2. (A) *Acacia tomentosa* in Chang Mai (Thailand);
(B) *Shorea robusta* in Mae Hong Son.

PLATE 3. *Shorea siamensis* in Lampang (Thailand).

These plants are cultivated as ornamentals in Chiang Mai, Mae Hong Son, and also in Lampang. Depending on its host, different vernacular names are attributed to *I. baumii* in Thailand: the local name of *Acacia tomentosa* is "Kra-Tin-Piman" and *I. baumii* on this host is called "Hed Kra-Tin-Piman" (Hed = mushroom); the local name of *Shorea robusta* is "Jigg" (North Thailand) or "Keng" (North-Eastern Thailand) so *I. baumii* on this host is known as "Hed Jigg" or "Hed Keng". Given that *I. baumii* is collected by a large number of people attracted by the medicinal properties of the basidiomata, the above identification key should enable non-specialists also to identity *I. baumii*.

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# Taxonomic studies in *Chrysoderma*, *Corneromyces*, *Dendrophysellum*, *Hyphoradulum*, and *Mycobonia*

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Abstract — Eight poorly known or unusual crustose and pileate basidiomycete species were studied. These included the type specimens of three monotypic genera: *Chrysoderma alboluteum* from Réunion is conspecific with *Cerocorticium molle*; *Dendrophysellum amurense* from the Russian Far East is a species of *Vararia*; and *Hyphoradulum conspicuum* belongs in *Pseudolagarobasidium* and is the first representative of the genus from Europe. *Corticium murrillii,* from Mexico, is congeneric with *Corneromyces kinabalui*. New combinations *Vararia amurensis*, *Pseudolagarobasidium conspicuum*, and *Corneromyces murrillii* are proposed. *Mycobonia flava* and *M. brunneoleuca* are macroscopically similar species with diagnostically distinct basidiospore shape and size. *Mycobonia disciformis* is accepted in *Mycothele*, and *Mycobonia winkleri* represents a species of unknown affinities. Recent molecular phylogenetic studies indicate that *Mycobonia* is embedded in *Polyporus* sensu stricto and is a synonym of *Polyporus*. Transferring *M. brunneoleuca* and *M. flava* to *Polyporus* requires the creation of the replacement names, *P. polyacanthophorus* and *P. epitheloides*.

Key words — *Amylocorticiales*, cyanophilous basidiospores, *Epithele*, *Favolus curtipes*, *Polyporales*

## Introduction

Tremendous advances in the systematics of basidiomycetes have been made in the last twenty years since the advent of molecular phylogenetics. Nevertheless, morphological studies are still essential to advance this discipline. In this paper, eight species of poorly known crustose or pileate basidiomycetes are described and illustrated. Type specimens of *Chrysoderma alboluteum, Corticium murrillii, Dendrophysellum amurense,* and *Hyphoradulum conspicuum* were examined. In addition, the genus *Mycobonia* (*Polyporales*) is revisited. Species of *Mycobonia* produce stipitate, pileate basidiomes with hyphal pegs penetrating a smooth hymenial surface. Four species have been

included in *Mycobonia* — *M. brunneoleuca*, *M. disciformis*, *M. flava*, and *M. winkleri* (Jülich 1976). *Mycobonia brunneoleuca* is considered a synonym of *M. flava* by some authors, and *M. disciformis* was transferred to the monotypic genus *Mycothele* by Jülich (1976). Little is known about *M. winkleri*, which has not been studied since it was first described in 1911. In this paper, *Mycobonia brunneoleuca* and *M. flava* are accepted as distinct species and transferred to *Polyporus* Adans. The literature concerning *M. flava* and *M. brunneoleuca* is critically examined. All the taxa are described and illustrated.

## Materials & methods

Thin, freehand sections from basidiomes were mounted in Melzer's reagent (Kirk et al. 2008) or in 1% (weight/volume) aqueous phloxine and 2% (w/v) aqueous potassium hydroxide. Cyanophily of basidiospore and hyphal walls was observed in 0.1% cotton blue in 60% lactic acid (Kotlaba & Pouzar 1964; Singer 1986). Basidiome sections were mounted in freshly prepared sulfovanillin solution (1 g vanillin, 3 ml distilled water, 8 ml concentrated sulfuric acid); a positive reaction was recorded if contents of the cystidium turned black. Drawings were made with a camera lucida attachment on an Olympus BH2 compound microscope. Q values were obtained from dividing average basidiospore length by width (Kirk et al. 2008). Basidiospores are sometimes scarce in specimens, thus Q values based on less than 30 basidiospores are approximate and indicated with an asterisk (*). Color codes are from Kornerup & Wanscher (1978) except that capitalized color names follow Ridgway (1912). Herbarium code designations follow Index Herbariorum (Thiers 2014). Accepted species names are in boldface.

## Taxonomy & discussion

*Chrysoderma alboluteum* Boidin & Gilles, Cryptog. Mycol. 12: 127. 1991.

FIGS 1–2, 10–11

= *Corticium molle* Berk. & M.A. Curtis, J. Linn. Soc., Bot. 10: 336. 1868 ["1869"].

≡ ***Cerocorticium molle*** (Berk. & M.A. Curtis) Jülich, Persoonia 8: 219. 1975.

= *Corticium armeniacum* Sacc., Syll. fung. 6: 637. 1888.

≡ *Terana armeniaca* (Sacc.) Kuntze, Revis. gen. pl. 2: 872. 1891.

= *Corticium ceraceum* Berk. & Ravenel, in Massee, J. Linn. Soc., Bot. 27: 150. 1890 ["1891"].

= *Cerocorticium bogoriense* Henn. & E. Nyman, Monsunia 1: 139. 1900 ["1899"].

= *Cerocorticium tjibodense* Henn., Monsunia 1: 139. 1900 ["1899"].

= *Corticium aureolum* Bres., Ann. Mycol. 9: 272. 1911.

BASIDIOME resupinate, widely effused, orbicular at first then confluent, ≤10 × 3 cm, rarely ≤1 m long, often breaking up into smaller pieces when dried, often slightly detached from substrate, ≤650 µm thick, ceraceous to corneous, smooth to slightly warted, white at first, then dull yellow, light orange (5A4), brownish orange (6C7), brown [7D(6–7)], Warm Buff, Russet, Tawny, Hazel, or Snuff Brown, sometimes slightly cracked on drying. CONTEXT white to cream-colored. MARGIN distinct, abrupt, edges detached or curling slightly away from

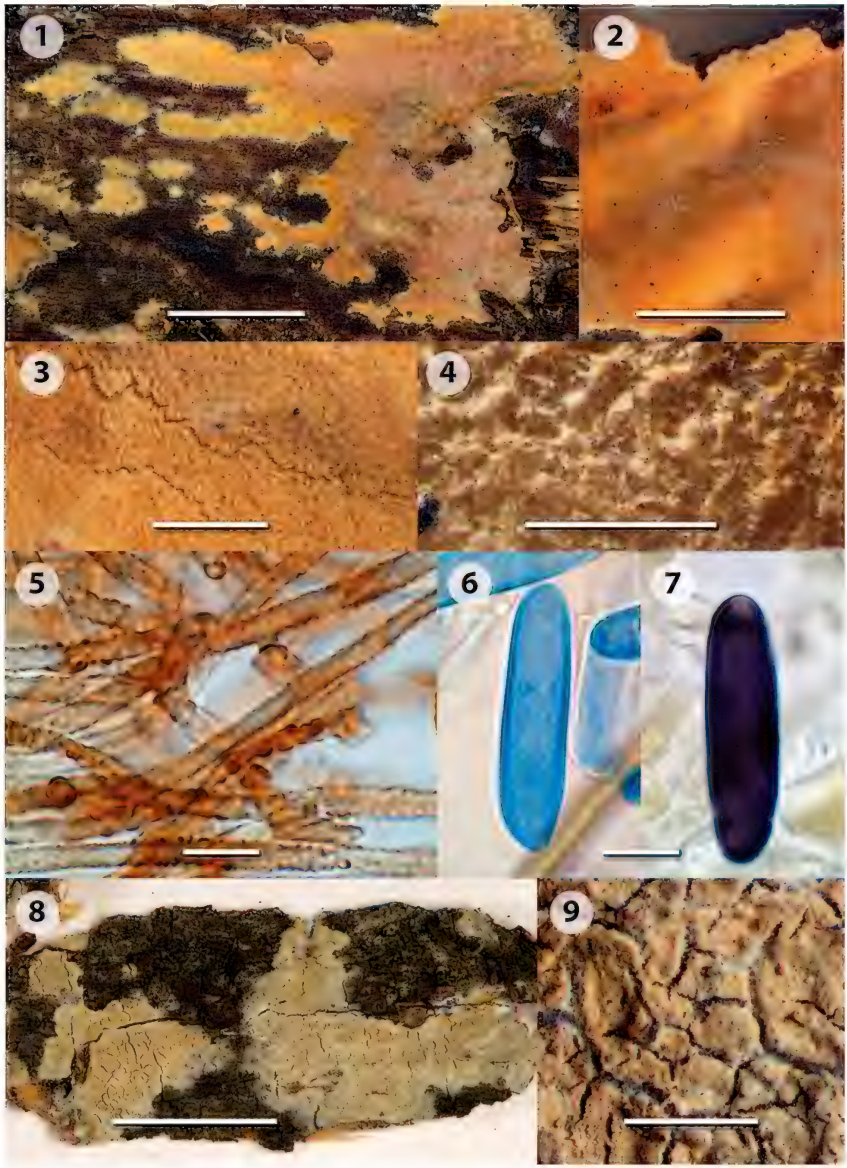
substrate, thickly fibrillose, or thinning out, concolorous with hymenium, white, or dark yellow.

Hyphal system monomitic with clamped generative hyphae. Subiculum ≤400 µm thick, a moderately dense, non-agglutinated tissue of more or less vertical hyphae; subicular hyphae (2–)3–6 µm diam, clamped, moderately branched, walls hyaline, thin to 1.5 µm thick, smooth, acyanophilous. Subhymenium ≤75 µm thick, a dense, compact but non-agglutinated tissue of vertically arranged hyphae; subhymenial hyphae 4–5.5 µm diam, clamped, frequently branched, walls hyaline, thin, smooth. Hymenium ≤100 µm thick, a dense, non-agglutinated palisade of hyphidia and basidia sometimes embedded in mucilaginous material. Hyphidia sometimes absent, when present filamentous with slight constrictions or swellings, sometimes with knobby outgrowths at apex, 35–70 × 2–4 µm diam, clamped at base, rarely branched, walls hyaline, thin or sometimes basally thickened, smooth. Basidia narrowly clavate with a long stalk, (40–)65–85(–100) × 7.5–10(–12) µm, clamped at base, often containing oil-like inclusions, walls hyaline, thin to slightly thickened, smooth, 4-sterigmate, sterigmata 7–10 × 1.5–2.2 µm. Basidiospores scarce to numerous, narrowly cylindrical to cylindrical, (13–)15–20(–23) × 4.5–8(–9) µm, average of five specimens 16.4–19.4 × 5.7–7.9, Q = (2.1–)2.6–3.1, often containing oil-like, cyanophilous materials, walls hyaline, thin, smooth, acyanophilous, not reacting in Melzer's reagent.

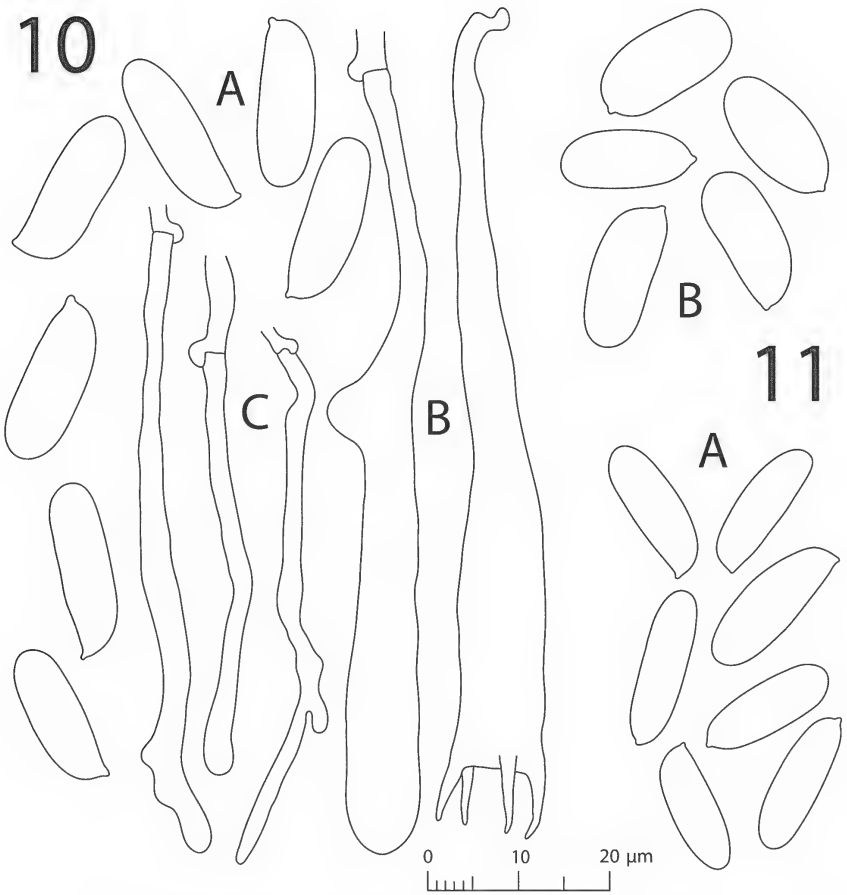
Habitat & distribution — On bark and wood of various dead angiosperms, occasionally on or under bark of living trees, throughout tropical and subtropical areas of North America, South America, Asia, and Africa.

Type specimens examined — **RÉUNION.** Anse des Cascades, sur branche tombée au bordure de l'eau, 6 avril 1990, J Boidin (LY 14412, **holotype** of *C. alboluteum*). **UNITED STATES.** South Carolina: ad corticeum ramulosque Corni, 1855, H Ravenel – Fungi Caroliniana, Fasc. III no. 29 (BPI 280736, 280735, **syntypes** of *C. ceraceum*).

Additional specimens examined — **BRAZIL.** Paraná: Curitiba, Capão da Imbuia, on decayed, dicot trunk, 16 Nov 1992, AAR de Meijer 2367 (CFMR). São Leopoldo: in ligno frondoso, 1907, Rick – Fungi Austro-Americani no. 240, as *Aleurodiscus alboroseus* Bres. (BPI 280723, as *C. ceraceum*). **MEXICO.** Orizaba, Rincon Grande and El Barrio, 4000 ft, on decorticate branch, 10–14 Jan 1910, WA & EL Murrill 54615 (BPI 280733, as *C. ceraceum*). **PUERTO RICO.** Luquillo Municipio: Sabana barrio, ridge above chicken farm along Rio Sabana, on decorticated hardwood, 30 Jun 1996, KK Nakasone (CFMR FP 150011). **RÉUNION.** St. Gilles I, en partie vivante *Casuarina equisetifolia* L. (bark), 26 avril 1985, J Boidin (LY 11356, as *C. alboluteum*); St. Gilles II, ravine, sur branche au sol, 26 avril 1985, J Boidin (LY 11373, as *C. alboluteum*). **SOUTH AFRICA.** No location, on bark, no date, P van der Bijl 13 (BPI 280731). **UNITED STATES.** Florida: Highlands Hammock, on bark of *Quercus* sp., 8 Feb 1937, CL Shear 330 (BPI 28038). Louisiana: Lafayette Parish, on rotten *Cornus florida* L., 7 May 1887, AB Langlois 1467 (BPI 289279, as *C. armeniacum*); St. Martinsville, on bark, 21 Apr 1897, AB Langlois 2389 (BPI 330776, as *C. ceraceum*). South Carolina: on *Cornus* sp., no date, H Ravenel, Ellis — North American Fungi no. 607 (BPI 280278).




Figs 1–9. ***Cerocorticium molle*** (FP 150011). 1. Basidiome. ***Chrysoderma alboluteum*** (LY 11356). 2. Basidiome. ***Corticium murrillii*** (isotype HUH 00290581). 3. Basidiome surface; 4. close-up of basidiome surface; 5. subicular hyphae in Melzer's reagent; 6. basidiospore with cyanophilous walls; 7. basidiospore with bluish black, amyloid walls in Melzer's reagent. ***Dendrophysellum amurense*** (holotype TAAM 015561). 8. Basidiome; 9. close-up of hymenial surface. Scale bars: 1, 8 = 10 mm; 2 = 2 mm; 3, 4, 9 = 1 mm; 5, 6 = 10 μm.




Figs 10–11. ***Corticium ceraceum*** (syntype BPI 0280736). 10. A. Basidiospores; B. basidia; C. hyphidia. ***Cerocorticium molle***. 11. Basidiospores: A. from BPI 0280731; B. from BPI 0280733.

Descriptions & illustrations — Boidin & Gilles (1991, as *C. alboluteum*), Burt (1926: 216, as *C. ceraceum*), Hjortstam (1983), Höhnel & Litschauer (1907, as *C. ceraceum*), Jülich (1975), Maekawa et al. (2003), Nakasone (2008, as *C. aureolum*), Talbot (1951, as *C. armeniacum*), Trierveiler-Pereira et al. (2009), Wu & Chen (1990).

Comments — *Cerocorticium molle* is characterized by yellow, orange, or brown, ceraceous to corneous basidiomes, simple hyphidia, large basidia, and large, cylindrical to narrowly cylindrical basidiospores. The basidiospores are variable in shape and size, sometimes within a single specimen. Höhnel's (1910) and Jülich's (1975) synonymies of *Cerocorticium bogoriense* and *C. tjibodense*, both from Java, with *C. molle* are accepted.

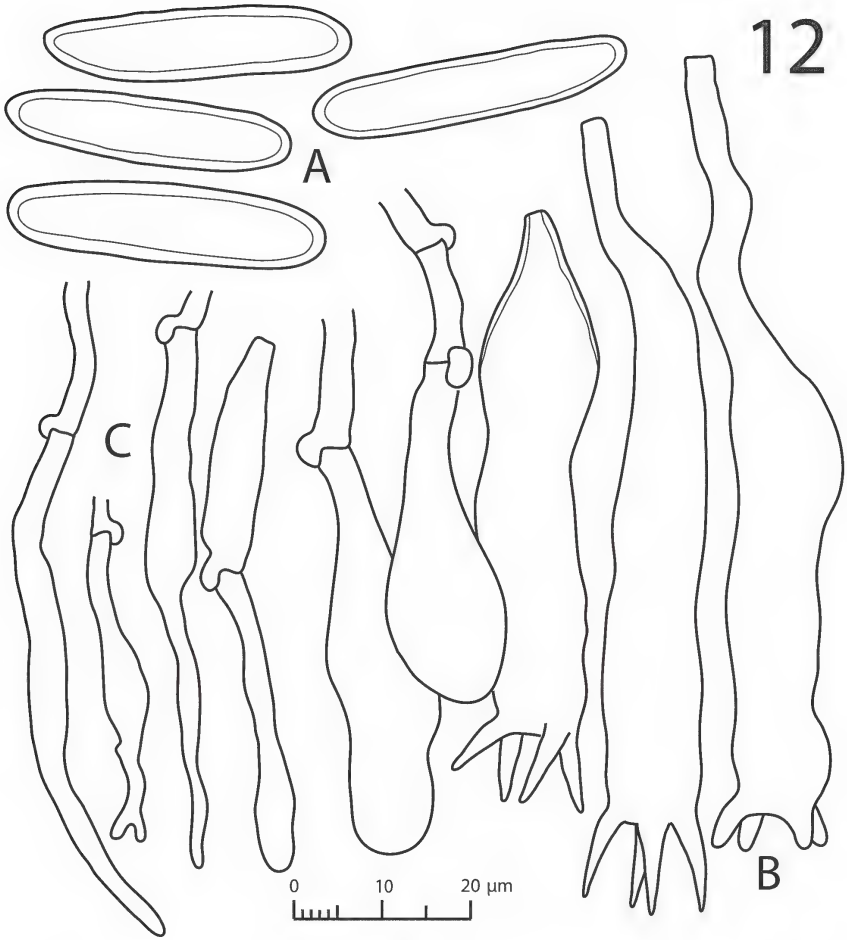
There is no doubt that *C. alboluteum* is conspecific with *C. molle* as suggested by Hjortstam & Larsson (1995). Although hyphidia were not observed in specimens of *C. alboluteum* examined, basidiomes and basidiospores are typical for the species. Boidin & Gilles (1991) noted that in *C. alboluteum* the basidiospore walls were pale yellow, producing a mass basidiospore color of yellowish orange, and calculated the average basidiospore size of three specimens as 12.8–14.6 × 4.4–5.1 µm, Q = 2.8–3.

*Corticium murrillii* Burt, Ann. Missouri Bot. Gard. 13: 289. 1926. FIGS 3–7, 12
≡ ***Corneromyces murrillii*** (Burt) Nakasone, **comb. nov.**
MYCOBANK MB812353

BASIDIOME resupinate, widely effused, ≤9 × 3.5 cm, loosely attached, ≤900 µm thick (Burt 1926), soft, fragile, membranous, abhymenial surface fibrous, felty, brown (7E8), turning black in KOH then fading, sometimes hyphal strands found under basidiome or in the substrate. HYMENIAL SURFACE smooth, even, finely farinaceous, orange white to pale orange [5A(2–3)], greyish orange [5B(4–5)], brownish orange [5C4–6)], yellowish brown (5D6), Cream-Buff, or Chamois, black in KOH then fading to light brown; cracks occasional. CONTEXT with a thin, dark brown layer next to substrate and a thicker, cream-colored upper layer. MARGIN thinning out, fibrillose, loosely attached or detached, concolorous with hymenium or developing a dark brown edge, sometimes poorly developed hyphal strands present.

HYPHAL SYSTEM monomitic with clamped generative hyphae. SUBICULUM ≤750 µm thick, a non-agglutinated tissue composed of brown, rough-walled subicular hyphae loosely arranged parallel to substrate, then hyphae turning into hymenium, becoming hyaline; subicular hyphae of two types: (a) next to substrate 3–5.5 µm diam, clamped, moderately branched, walls yellow to brown, ≤1.1 µm thick, smooth or ornamented with tiny tubercles; (b) in upper subiculum 3–6 µm diam, clamped, moderately branched, walls hyaline, thin, smooth. SUBHYMENIUM a non-agglutinated, scarcely differentiated tissue of upright hyphae; subhymenial hyphae 2.2–5 µm diam, clamped, moderately branched, walls hyaline, thin, smooth. HYMENIUM a palisade of hyphidia and basidia. HYPHIDIA scarce, filamentous, obclavate, or narrowly clavate, (25–)35–65 × (3–)4–6.5(–10) µm, clamped at base, walls hyaline, thin, smooth. BASIDIA collapsing soon after ejecting spores, obclavate at first then clavate to cylindric, usually with a distinct stalk, (35–)40–90(–110) × 10–14 µm, clamped at base, walls hyaline, thin or slightly thickened at base, smooth, 4-sterigmate, sterigmata

FIGS 12–13. ***Corticium murrillii*** (holotype BPI 0282179). 12. A. Basidiospores; B. basidia; C. hyphidia. ***Dendrophysellum amurense*** (holotype TAAM 015561). 13. A. Basidiospores; B. basidia; C. gloeocystidia; D. subicular hypha; E. skeletal-like hyphae; F. dichohyphidia.


12
A
C
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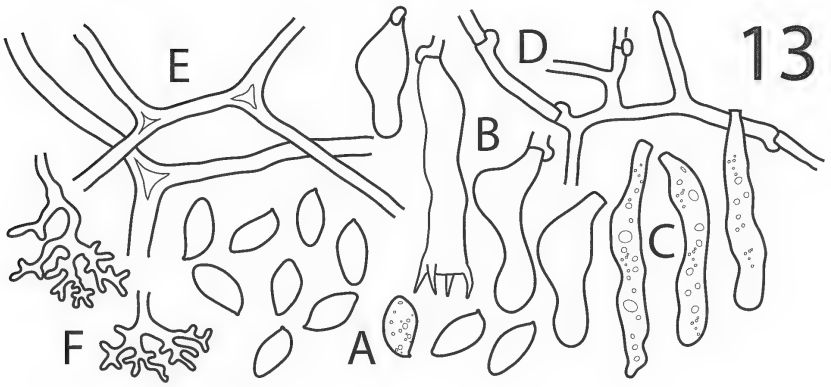
20 µm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≤17 × 3.5 µm. Basidiospores abundant, narrowly cylindric to allantoid, (25–)28–40(–43) × (7.2–)8–11(–11.5) µm, averages of three specimens 28.9–29.6 × 8.7–10.4 µm, Q = 2.8–3.4, average of isotype at FH 34.4 ± 4.2 × 9.9 ± 0.9 µm, Q = 3.5 ± 0.4, walls hyaline, occasionally pale yellow, thin to 1.3 µm thick, smooth, cyanophilous, dark blue-black in Melzer's reagent.

Habitat & distribution — On bark and wood of dead angiospermous branches and logs in subtropical and tropical Central and South America.

Type specimens examined — **MEXICO.** Jalapa, 5000 ft, on bark of decaying log, 12–20 Dec 1909, WA & EL Murrill 182 (BPI 0282179, **holotype**; NY 00776553, NY 00562612, and FH HUH-00290581, **isotypes**).

Specimens examined — **COLOMBIA.** Magdalena, Sierra Nevada de Santa Marta, Reserva Forestal San Lorenzo, on wood, 17–19 June 1978, L Ryvarden 16070 (O, as "*C. kinabalui*"). **ECUADOR.** Sucumbíos Province: Reserva Natural de Cuyabeno, 300 m.a.s.l., on hanging branch, 28 June–15 July 1993, M Nuñez 306 (O F–902593, as "*C. kinabalui*" ).

Descriptions & illustrations — Burt (1926), Liberta (1969).

Comments — *Corneromyces murrillii* is an uncommon and unusual species characterized by a soft fragile basidiome, hyphidia, large basidia, and large narrowly cylindric to allantoid basidiospores with amyloid and cyanophilous walls. There was a wide range in basidium and basidiospore size among the specimens examined. *Corneromyces murrillii* is similar to *C. kinabalui* Ginns from Borneo, which has brown aculeate basidiomes, smooth brown subicular hyphae, and brown basidiospores (Ginns 1976). Basidiospore sizes in the two species are similar. The average basidiospore size of the isotype of *C. kinabalui* at BPI, BPI 0290583, is 27 ± 2.9 × 9.1 ± 1.1 µm, Q = 3 ± 0.3.

One isotype of *C. murrillii* (NY 00776553) is a large collection that is intermixed with small basidiome fragments of *Rhizochaete radicata* (Henn.) Gresl. et al. Hjortstam & Ryvarden (2001, 2008) erroneously reported *C. kinabalui* from Columbia and Ecuador; two of the voucher specimens were examined and identified as *C. murrillii*.

The affinities of *Corneromyces* Ginns are not known. Ginns (1976) considered creating a new family for *Corneromyces* but placed it instead in *Coniophoraceae* Ulbr. Citing the strongly amyloid, brown, thick-walled basidiospores, Jülich (1979) proposed the family *Corneromycetaceae* Jülich. Recent molecular phylogenetic studies have identified a new order, *Amylocorticiales* K.H. Larss. et al. This order is characterized by varied basidiome habit and hymenophore configuration, a monomitic nodose-septate hyphal system, and smooth thin- or thick-walled basidiospores that are amyloid in most species (Binder et al. 2010). *Corneromyces* may belong in the *Amylocorticiales,* which is sister to the *Agaricales* Underw., instead of with *Coniophora* DC. and allies in the *Boletales* E.-J. Gilbert.

*Dendrophysellum amurense* Parmasto, Consp. syst. cortic.: 206. 1968.
FIGS 8–9, 13–15

≡ ***Vararia amurensis*** (Parmasto) Nakasone, **comb. nov.**
MYCOBANK MB812355

BASIDIOMES resupinate, effused, beginning as circular to irregular colonies, then coalescing, ≤5 × 20 mm, adnate, thin, ≤150 µm thick, subceraceous, smooth to finely granulose over the irregular contours of the substrate, greyish yellow [4(B–C)(3–4)], greyish orange [5B(3–4)], to brownish orange (5C3), rimose, exposing white, felty to cottony context; cottony white mycelial tissue developed in substrate and occasionally beneath basidiome. MARGIN adnate, thinning out, white, farinaceous.

HYPHAL SYSTEM dimitic with clamped generative hyphae and aseptate dichohyphidia. MYCELIAL TISSUE cottony, white, composed of skeletal-like hyphae; hyphae 2.2–3.5 µm diam, occasionally clamped or appearing aseptate, sparsely branched, straight, non-staining, walls hyaline, thin to thick, smooth. SUBICULUM ≤100 µm thick, basal layer next to substrate a compact, agglutinated tissue of short-celled hyphae arranged more or less parallel to substrate, then hyphae becoming upright, mostly indistinct and degraded although with a few, intact, phloxine-stained hyphae; subicular hyphae from basal layer 3–5 µm diam, clamped, frequently branched, walls hyaline, thin, smooth; hyphae of upper subiculum 1.5–2.2 µm diam, clamped, moderately branched, walls hyaline, thin, smooth. SUBHYMENIUM AND HYMENIUM indistinct, composed of dichohyphidia, gloeocystidia, and basidia intermixed with abundant, coarse, hyaline crystals. DICHOHYPHIDIA scattered in hymenium, not enclosed, dendriform, ≤20 × 20 µm, with a main stalk, 2–2.5 µm diam, and multiple, short branches, walls hyaline, slightly thickened, smooth, cyanophilous, dextrinoid. GLOEOCYSTIDIA scarce, inconspicuous, cylindrical to narrowly clavate, occasionally papillate, 23–27 × 3–4 µm, clamped at base, protruding ≤15 µm, containing oil-like material, negative in sulfovanillin, walls hyaline, thin, smooth. BASIDIA suburniform at first, then narrowly cylindrical, flexuous, about 26 × 5 µm, clamped at base, protruding ≤10 µm, 4-sterigmate, walls hyaline, thin, smooth. BASIDIOSPORES numerous, agglutinated, often collapsed, subfusiform to pip-shaped (in face view), 6–8(–9.3) × 3–3.7(–4) µm, $x$ = 7.1 ± 0.7 × 3.3 ± 0.3 µm, Q = 2.1 ± 0.3, walls hyaline, thin, smooth, acyanophilous, faintly amyloid.

HABITAT & DISTRIBUTION — On bark of dead *Picea*; known from the type locality in northeastern Asia.

TYPE SPECIMEN EXAMINED — **RUSSIA.** KHABAROVSK REGION: Selikhino, Kabansopka, on bark of fallen trunk of *Picea jezoensis* (Siebold & Zucc.) Carrière, 18 Aug 1961, E Parmasto (TAAM 015561, **holotype**).

Comments — *Vararia amurensis* is characterized by clamped generative hyphae, dextrinoid and cyanophilous dendriform dichohyphidia, gloeocystidia, suburniform basidia, and subfusiform amyloid basidiospores. A typical catahymenium was not observed. Mature basidia are rare, and gloeocystidia are inconspicuous and easily overlooked. It is morphologically similar to *V. mediospora* var. *makokouensis* Boidin et al. from Gabon, which has basidiospores of the same size and shape but lacks clamp connections (Boidin et al. 1980). Parmasto (1968: 146) placed *Dendrophysellum* Parmasto in *Corticiaceae* subfam. *Aleurodiscoideae* Parmasto, but it is morphologically similar to taxa in *Vararia* sect. *Fusamyspora* Boidin & Lanq. that have dextrinoid and cyanophilous dendrohyphidia, smooth or slightly ornamented amyloid basidiospores, and sulfovanillin-negative gloeocystidia (Boidin & Lanquetin 1975). Thus, the monotypic genus *Dendrophysellum* is placed in synonymy under *Vararia* and *D. amurense* is transferred to *Vararia*.

*Hyphoradulum conspicuum* Pouzar, Česká Mykol. 41: 26. 1987. Figs 16–17, 25

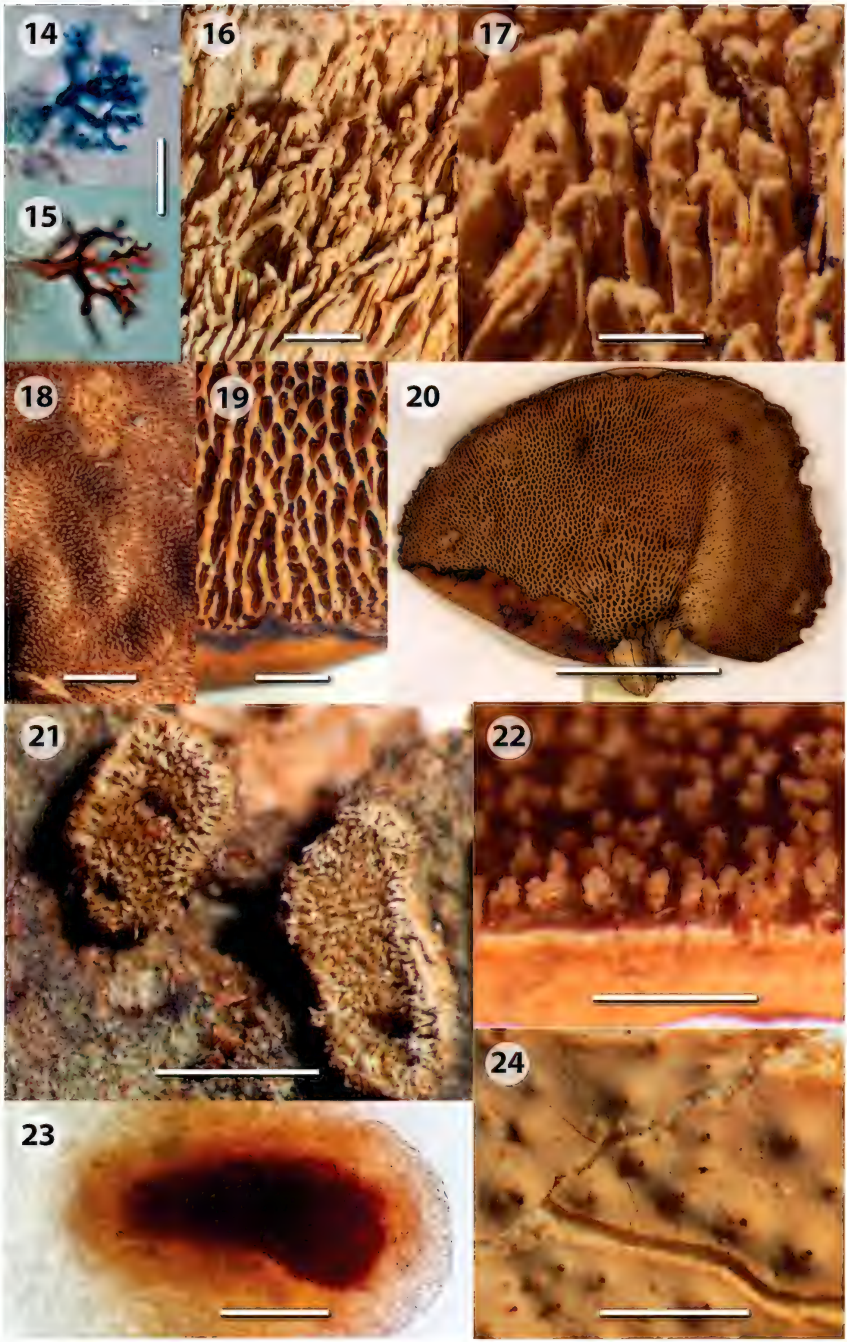
≡ ***Pseudolagarobasidium conspicuum*** (Pouzar) Nakasone, **comb. nov.**

MycoBank MB812356

Basidiome resupinate, widely effused, soft, fragile, cretaceous, spinose, yellowish white (4A2), greyish yellow (4B3), or greyish orange (5B3), no color change with KOH; cracks absent. Hymenial surface composed of fragile, brittle, soft, cretaceous or chalky aculei, ≤2 aculei per mm, ≤3.5 mm long, terete to conical then gradually tapering to an acute or rounded apex, single at first then fused at base or along entire length, occasionally reticulate, smooth or studded with tiny, round tubercles, apices concolorous with base of aculei or pale yellow, often broken off. Margin cream white, byssoid, fibrillose.

Hyphal system monomitic with clamped generative hyphae. Aculei composed of non-agglutinated tramal hyphae arranged in a fascicle with embedded tramal cystidia curving into hymenium, at aculeal apex terminal hyphae undifferentiated, smooth; tramal hyphae (1.5–)2–3(–4) µm diam, clamped, sparingly branched, even, walls distinct, hyaline, thin, smooth, sometimes weakly cyanophilous. Subiculum 300–700 µm thick, a non-

Figs 14–24. ***Dendrophysellum amurense*** (holotype TAAM 015561). 14. Dichohyphidium with cyanophilous walls; 15. dichohyphidium with dextrinoid walls in Melzer's reagent. ***Hyphoradulum conspicuum*** (isotype PRM 834887). 16. Aculei; 17. close-up of aculei. ***Polyporus polyacanthophorus*** (BPI 0261328). 18. Hyphal pegs from hymenial surface. ***Favolus curtipes*** (isotype HUH 00290582). 19. Close-up of poroid surface; 20. poroid surface of basidiome. ***Mycothele disciformis*** (isotype BPI 0261300). 21. Close-up of basidiomes. ***Polyporus epitheloides*** (BPI 0261319). 22. Close-up of apically encrusted hyphal pegs. ***Mycobonia winkleri*** (holotype F–15807). 23. Cross-section of "hyphal peg" or bulbil; 24. close-up of hymenial surface with "hyphal pegs" or bulbils. Scale bars: 14, 15 = 10 µm; 16, 18, 19 = 2 mm; 17, 21, 24 = 1 mm; 20 = 20 mm; 22 = 0.5 mm; 23 = 50 µm.


14
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agglutinated tissue; subicular hyphae 1–5 µm diam, clamped, walls hyaline, thin, smooth. SUBHYMENIUM ≤40 µm thick, composed of short-celled hyphae in a dense non-agglutinated tissue; subhymenial hyphae 2–3 µm diam, clamped, frequently branched, walls hyaline, thin, smooth. HYMENIUM ≤35 µm thick, a dense palisade of hyphidia, cystidia, and basidia. HYPHIDIA scarce, inconspicuous, filamentous to subulate, 15–23 × 1.5–3 µm, clamped at base, walls hyaline, thin, smooth. CYSTIDIA of two types: (a) arising from aculei trama, subiculum, and subhymenium, abundant, embedded, broadly cylindrical, clavate, or obclavate, often strangulated or moniliform, sometimes with a lateral lobe, stalked, apex obtuse, occasionally branched, (27–)40–80 × 5–10 µm, tapering to 1.5–3 µm diam at base, with a basal clamp, often with honey yellow, refractive contents, walls hyaline, thin, smooth, negative in sulfovanillin; (b) arising from hymenium, rare, clavate to cylindrical but sometimes with a small, lateral beak, 11–15 × 4–5 µm, with a basal clamp, walls hyaline, thin, smooth. BASIDIA clavate, often with a distinct stalk, (16–)20–35 × 5–6 µm, clamped at base, walls hyaline, thin, smooth, 4-sterigmate. BASIDIOSPORES ellipsoid with a small apiculus, (4.8–)5–5.8(–6) × 3.5–4.4 µm, average of isotype 5.4 ± 0.4 × 4 ± 0.2 µm, Q = 1.3 ± 0.1, filled with numerous oil-like globules, walls hyaline, slightly thickened, smooth, cyanophilous, not reacting in Melzer's reagent.

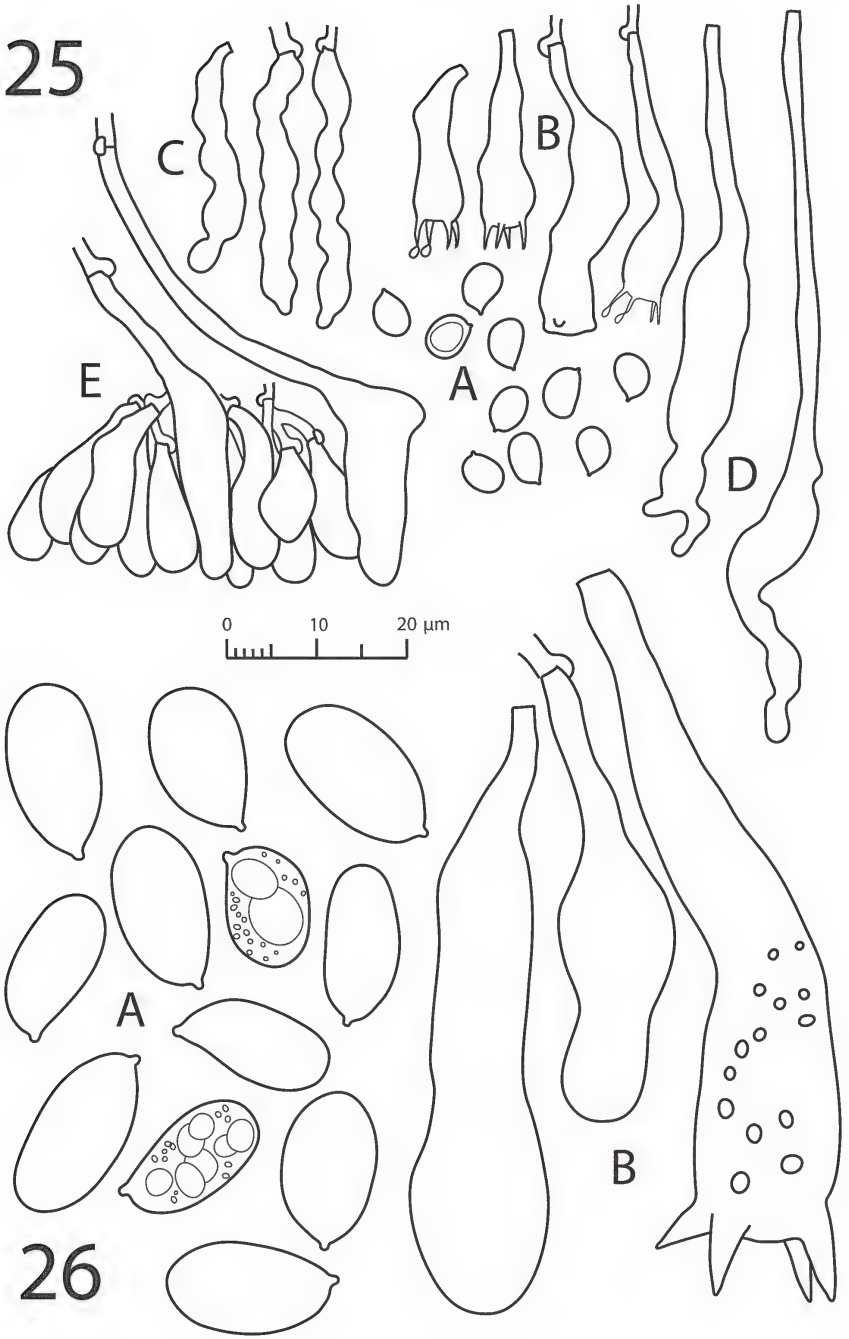
HABITAT & DISTRIBUTION — Saprophytic on wood and bark of dead *Cornus;* known from the type location, Bohemia.

TYPE SPECIMENS EXAMINED — **CZECH REPUBLIC.** BOHEMICA: "Velká hora" hill near Karlštejn, on base of dead *Cornus mas* L., 2 Oct 1981, Z Pouzar (PRM 834886, **holotype**; PRM 834887, **isotype**).

COMMENTS — *Pseudolagarobasidium conspicuum* is characterized by soft, brittle, cretaceous or chalky aculei, strangulated or monilioid cystidia with honey-yellow contents, and ellipsoid basidiospores with slightly thickened, cyanophilous walls. Microbinding hyphae were not observed. Pouzar (1987) noted that old collapsed basidiospores have dextrinoid walls, which was not observed in this study. This is the first species of *Pseudolagarobasidium* J.C. Jang & T. Chen reported from Europe. The description above is based partially on Pouzar's (1987) observations. *Hyphoradulum conspicuum* is transferred to *Pseudolagarobasidium*, and *Hyphoradulum*, a monotypic genus, becomes a synonym of *Pseudolagarobasidium*.

This species is most similar to *P. pronum* (Berk. & Broome) Nakasone & D.L. Lindner with respect to color and texture of the basidiome.

FIGS 25–26. ***Hyphoradulum conspicuum*** (isotype PRM 834887). 25. A. Basidiospores; B. basidia; C. hymenial cystidia; D. tramal cystidia; E. section through hymenium with tramal cystidia and immature basidia. ***Polyporus polyacanthophorus*** (TENN 57579). 26. A. Basidiospores; B. basidia.


25
C
B
E
A
D
0
10
20 µm
A
B
26

*Pseudolagarobasidium pronum* develops microbinding hyphae and has slightly smaller basidiospores (4–5.5 × 3–3.7(–4.3) µm) with weakly cyanophilous walls, whereas *P. conspicuum* lacks microbinding hyphae and has distinctly cyanophilous basidiospore walls. In addition, cystidia in *P. pronum* do not contain refractive, honey-yellow contents. *Pseudolagarobasidium conspicuum* is known from Europe, whereas *P. pronum* is reported from Asia, Australia, Sierra Leone (Nakasone & Lindner 2012), and a first report from Jamaica (Runaway Bay, on *Calliandra* sp., 12 Feb 2006, F. Dämmrich 8139 at CFMR). See Nakasone & Lindner (2012) for a description of *P. pronum* and other species of *Pseudolagarobasidium*.

### The genus *Mycobonia*

*Mycobonia* Pat. was erected with the generic type *Hydnum flavum* Berk. (Patouillard 1894). *Mycobonia* was substituted for the illegitimate *Bonia* Pat., which had *Bonia papyrina* Pat. as its generic type (Patouillard 1892). These two generic names are not homotypic; thus, *Mycobonia* was published as a new genus rather than a replacement name. For a detailed nomenclatural history of *Mycobonia*, see Jülich (1976) and Martin (1939). One important feature of *Mycobonia* is the dense stand of hyphal pegs penetrating the smooth hymenial surface. Hyphal pegs are not restricted to *Mycobonia* but are produced in a number of basidiomycete species. For a key to basidiomycete taxa with hyphal pegs see Nakasone (2013). *Mycobonia* is readily distinguished from other taxa with hyphal pegs and non-septate basidia by its substipitate and pileate basidiomes.

The classification of *Mycobonia* is controversial because of its unique combination of morphological features. Donk (1964: 294) placed *Mycobonia* in the *Stereaceae* Pilát even as he noted a close relationship to *Pseudofavolus* Pat. in the *Polyporaceae* Fr. ex Corda. Jülich (1982: 186) created *Mycoboniaceae* Jülich for *Mycobonia,* placing the family in the *Polyporales*. Later, Singer (1986: 171) reduced *Mycoboniaceae* to a synonym of *Polyporaceae*. Other researchers also noticed striking morphological similarities between *Mycobonia* and *Polyporus* (Corner 1984: 102; Krüger 2002; Krüger & Gargas 2010; Ryvarden 1991: 213, 2010: 119) and between *Mycobonia* and *Pseudofavolus* (Corner 1984: 36, Krüger 2002, Krüger & Gargas 2010, Singer 1986: 171). Authors have generally agreed that *Pseudofavolus* is closely related to *Polyporus* s.s. (Núñez & Ryvarden 1995: 68, Ryvarden 1991: 213), while some consider *Pseudofavolus* a synonym of *Polyporus* (Corner 1984: 35, Krüger 2002, Krüger & Gargas 2010).

Molecular phylogenetic studies show that *Mycobonia* and *Pseudofavolus* are sister taxa embedded in the core polyporoid clade (Binder et al. 2013; Krüger 2002; Krüger & Gargas 2004, 2010; Sotome et al. 2008), confirming

morphological observations. Based on phylogenetic studies and morphological similarities, Krüger (2002) and Krüger & Gargas (2010) reduced *M. flava* to a subspecies of *Polyporus curtipes* (Berk. & M.A. Curtis) Ryvarden. While agreeing with these authors that the molecular and morphological evidence overwhelmingly indicates that *Mycobonia* is a synonym of *Polyporus*, significant differences in ITS sequences and basidiospore shape and size argue for the recognition of *M. flava* and *M. brunneoleuca* as distinct species. Transfer of these taxa requires replacement names because both species epithets are preoccupied in *Polyporus*.

*Mycobonia brunneoleuca* (Berk. & M.A. Curtis) Pat., Bull. Soc. Mycol. France 16: 181. 1901 (1900). FIGS 18, 26–27

≡ *Hydnum brunneoleucum* Berk. & M.A. Curtis, Trans. Linn. Soc. London 22: 129. 1857, non *Polyporus brunneoleucus* Berk. 1846.

≡ ***Polyporus polyacanthophorus*** Nakasone, **nom. nov.**

MYCOBANK MB812357

ETYMOLOGY: from the Greek, *poly-* (many) + *acantha* (spine) + *-phorus* (bearing), referring to the numerous hyphal pegs in the hymenial surface.

BASIDIOME pileate, sessile or substipitate, coriaceous, flabellate, reniform. PILEUS galeaeform or helmet-shaped, ≤10 × 8 cm; upper surface smooth, becoming radially rugulose, bright yellow when fresh, drying to dull greyish orange (5B6), brown (7D7), reddish brown (9E6), Vinaceous-Russet, Pecan Brown, or Kaiser Brown. STIPE reduced, usually black, 3.5–9 mm diam, attached to substrate by a thin, circular pad, ≤8–13 mm diam. CONTEXT ≤4 mm thick at base, thinning to 0.3 mm at pileus edge, pale orange (5A3), coriaceous. HYMENIAL SURFACE appearing smooth but densely covered with minute, conical hyphal pegs, ≤330 × 40–80 µm, 9–12 pegs per mm, becoming fimbriate at apex, purplish tan when fresh, drying to greyish orange (5B3), brownish orange to light brown [6(C–D)5], or Cinnamon Buff.

HYPHAL SYSTEM dimitic with clamped generative and aseptate skeleto-binding hyphae. HYPHAL PEGS a dense fascicle of non-agglutinated, sparsely branched skeleto-binding hyphae, ≤330 µm long, originating 100–150 µm below hymenium, projecting ≤180 µm, encrusted at apex with coarse, irregular, hyaline crystals; hyphae rigid, tapering to acute apex, ≤3 µm, walls hyaline to light brown, slightly thick, smooth, cyanophilous, weakly dextrinoid. CONTEXT a densely interwoven, non-agglutinated tissue composed mostly of skeleto-binding hyphae and some generative subicular hyphae; subicular hyphae 3–6.5 µm diam, clamped, strangulated, staining in phloxine, walls hyaline, thin, smooth; skeleto-binding hyphae (0.5–)1.5–5.5 µm diam, occasionally inflated ≤12 µm diam, then tapering to tips, with a narrow lumen, aseptate, rarely to

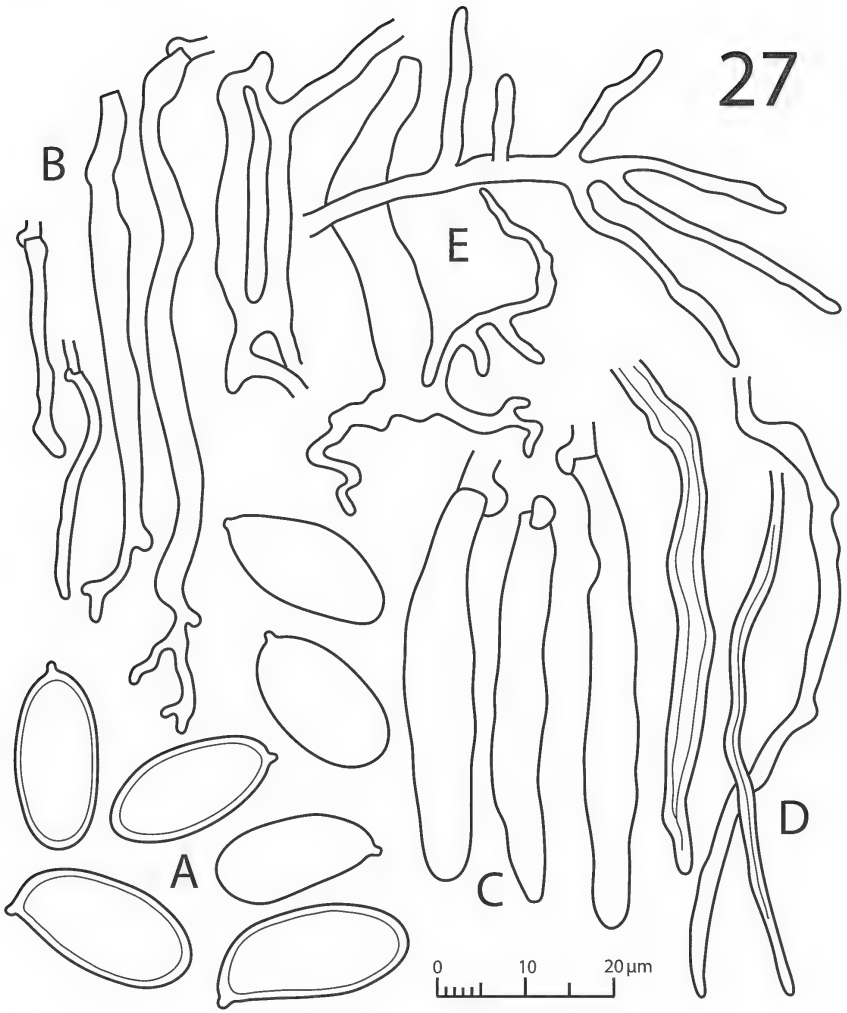



Fig. 27. ***Polyporus polyacanthophorus*** (NY 00536422). A. Basidiospores; B. thin-walled hyphidia; C. cystidia; D. hyphidia from hyphal pegs; E. skeleto-binding hyphae from context of NY 00543220.

extensively branched, walls hyaline, ≤1.5 µm thick, smooth, acyanophilous, not reacting in Melzer's reagent. Subhymenium a dense, thickening, non-agglutinated tissue of upright, short-celled hyphae; subhymenial hyphae 3.5–4.5µm, clamped, frequently branched, walls hyaline, thin, smooth. Hymenium a dense palisade of hyphidia, cystidia, and basidia. Hyphidia or two types: (a) inconspicuous, filamentous, often with short branches at apex, (23–)32–60

(–80) × 2–4 µm, clamped at base, walls hyaline, thin, smooth; (b) numerous, acicular or narrowly cylindrical then tapering to a subacute or acute tips, 1.5–4 µm diam, with a narrow lumen, aseptate, sparsely branched, walls hyaline, slightly thick to thick, smooth, acyanophilous, not reacting in Melzer's reagent (may be interpreted as terminal ends of skeleto-binding hyphae). CYSTIDIA of two types: (a) rare, inconspicuous, embedded, subfusiform to cylindrical, tapering slightly to apex, 45–55 × 6–7.5 µm, clamped at base, walls hyaline, thin, smooth; (b) rare, obclavate, an enlarged bulbous base tapering to apex, 25–45 × (6–)10–15 µm, aseptate, walls hyaline, ≤1 µm thick, smooth, acyanophilous, not reacting in Melzer's reagent. BASIDIA scarce, clavate with a stalk, ≤80 × 10–16 µm, clamped at base, walls hyaline, thin, smooth, with 4-sterigmata. BASIDIOSPORES cylindrical to narrowly ellipsoid or broadly subfusiform with a small, distinct, hyaline apiculus, (13–)16–24(–26.5) × (7.2–)8–11(–12.3) µm, average of three specimens 17.3–21 × 9.4–10.1 µm, Q = 1.9–2.2, containing oil-like material, walls hyaline to light brown, thin to 0.7 µm thick, smooth, acyanophilous or weakly cyanophilous, not reacting in Melzer's reagent.

HABITAT & DISTRIBUTION — On logs, branches and twigs of dead hardwoods throughout Central and South America and the Caribbean region.

TYPE SPECIMEN EXAMINED — **VENEZUELA**. Fendler 129 (FH HUH-00290586, **isotype** of *H. brunneoleucum*).

REPRESENTATIVE SPECIMENS EXAMINED — **BRAZIL**. PROV. SÃO PAULO: S. Framisco dos Campos, Dec 1896, F Noark 333 (S F–177421); Caldas, pnu. Miras Gerais, Regnell (S F–249624). **COLUMBIA.** DEPT. DEL CAUCA: Cordillera Central, Hoya del Rio Palo, Ta Tolda, 1944, J Ceratrecas 19440 (BPI 0261323); Munchique, 2700 m elev., on dead wood, 5 May 1968, AL Welden 7318 (NY 00536422). **COSTA RICA**. PUNTARENAS PROVINCE: Monteverde, on recently cut small trees, 8 Jan 1973, AL Welden 3303 (NY 00543220); Sta. Elena, road to Elena Biological Reserve, on fence post, 17 Mar 1999, RH Petersen 10256 (TENN 57579). SAN JOSÉ PROVINCE: San Isidro de Coronado, on fallen log, 21 Jun 1972, AL Welden 8338 (NY 00536420); Monté Zurquí, alt. 2000–2500 m., on log, 13 Feb 1926, PC Standley & J Valerio no. 48084 (BPI 261325). Dota, Guadeloupe, Finca Jaular, km 66 on Interamerican Hwy, 1 Jul 1998, RH Petersen 9471 (TENN 56445). HEREDIA PROVINCE: Cerro Central de Zurqui, 1600 m., on dead log, 27 Dec 1929, CW Dodge no. 633 (BPI 261320). **HONDURAS**. Tegucigalpa, Escuela Agricola Panamericana, 31 Dec 1951, AS Mueller (BPI 261322). **PANAMA**. CHIRIQUÍ PROVINCE: valley of upper Rio Chiriquí Viejo, 1600–1800 m., 10 Jul 1935, GW Martin 2714 (BPI 261324, as "*M. flava*"); 6 Jul 1953, GW Martin 2519 (BPI 261238, as "*M. flava*"); 7 Jul 1935, GW Martin 2631 (NY 00536417, as "*M. flava*"). **PARAGUAY**. Asunción, San Antonii, July 1893, Malme (S F–249621). **PUERTO RICO**. Guajataca Community Forest, Verada, Nueva Trail, on deciduous wood, 26 Jun 1996, L Ryvarden (CFMR PR 5160).

DESCRIPTIONS & ILLUSTRATIONS — Gerlach & Loguercio-Leite (2011), Martin (1939: 248, figs 13–16, as *M. flava*), Jülich (1976, figs 1–2 only), Reid (1976: 191, fig. 2).

COMMENTS — *Polyporus polyacanthophorus* is a pileate species characterized by a dense stand of hyphal pegs in the hymenium and large, cylindrical to

ellipsoid basidiospores. Although considered a synonym of *P. epitheloides* (as *M. flava*) by some mycologists, it can be differentiated by its larger basidia and broader basidiospores. In addition, the thin-walled, fusiform to cylindrical cystidia observed in *P. polyacanthophorus* are not present in *P. epitheloides*. Reid (1976) postulated that *P. polyacanthophorus* (as *M. brunneoleuca*) prefers higher elevation habitats than *P. epitheloides* (as *M. flava*).

The description above is based on Martin (1939), Reid (1976), and personal observations. A replacement name is proposed for *H. brunneoleucum* because the species epithet is occupied in *Polyporus*. Although Martin (1939: 247) considered *M. brunneoleuca* a synonym of *M. flava*, the specimens he referenced from Panama are redetermined here as *P. polyacanthophorus*. Similarly, the drawings of *M. flava* in Jülich (1976, Fig. 2) of an Argentinian specimen probably represent *P. polyacanthophorus* based on the basidiospore shape and size.

*Mycobonia disciformis* G. Cunn., Trans. Roy. Soc. New Zealand 83: 635. 1956.

FIGS 21, 28

≡ ***Mycothele disciformis*** (G. Cunn.) Jülich, Persoonia 8: 452. 1976.

BASIDIOMES resupinate, scattered to gregarious, disciform, centrally attached to substrate, orbicular to elongate, 1–10 mm diam, ≤0.5 mm thick, firm, membranous to ceraceous, spinose because of numerous hyphal pegs, exterior surface dark brown. HYMENIAL SURFACE smooth with numerous hyphal pegs penetrating surface, cream, dull sulfur-yellow, or light brown. HYPHAL PEGS cylindrical, tapering to a subacute apex, 20–30 per mm. MARGIN distinct, abrupt, free, slightly involute.

HYPHAL SYSTEM monomitic with clamped generative hyphae. HYPHAL PEGS originating deep in subicular trama, a dense, agglutinated fascicle of hyphae with an central column of coarse, hyaline crystals, ≤1000 × 45 µm, protruding ≤135 µm. SUBICULUM ≤800 µm thick with a basal layer of compact hyphae arranged parallel to substrate, then hyphae becoming upright, forming a dense but non-agglutinated tissue; subicular hyphae 2–3 µm diam, clamped, moderately branched, walls hyaline to brown, thin to slightly thick, smooth. HYMENIUM ≤70 µm thick, a dense palisade of hyphidia and basidia. HYPHIDIA filamentous, occasionally branched at apex, 20–40 × 2–2.5 µm, clamped at base, walls hyaline, thin, smooth. BASIDIA fragile, scarce, cylindrical to narrowly clavate, sometimes with a short, stalk-like base, (38–)45–60 × (7–)9–11(–14) µm, clamped at base, walls hyaline, thin, smooth, 4-sterigmate, sterigmata 7–10 × 1.5–2 µm. BASIDIOSPORES scarce, globose to subglobose or broadly ellipsoid, 8–13.5 × (6.5–)7–9(–10) µm, filled with oil-like globules, walls hyaline, thin, smooth, acyanophilous or weakly cyanophilous, not reacting in Melzer's reagent.

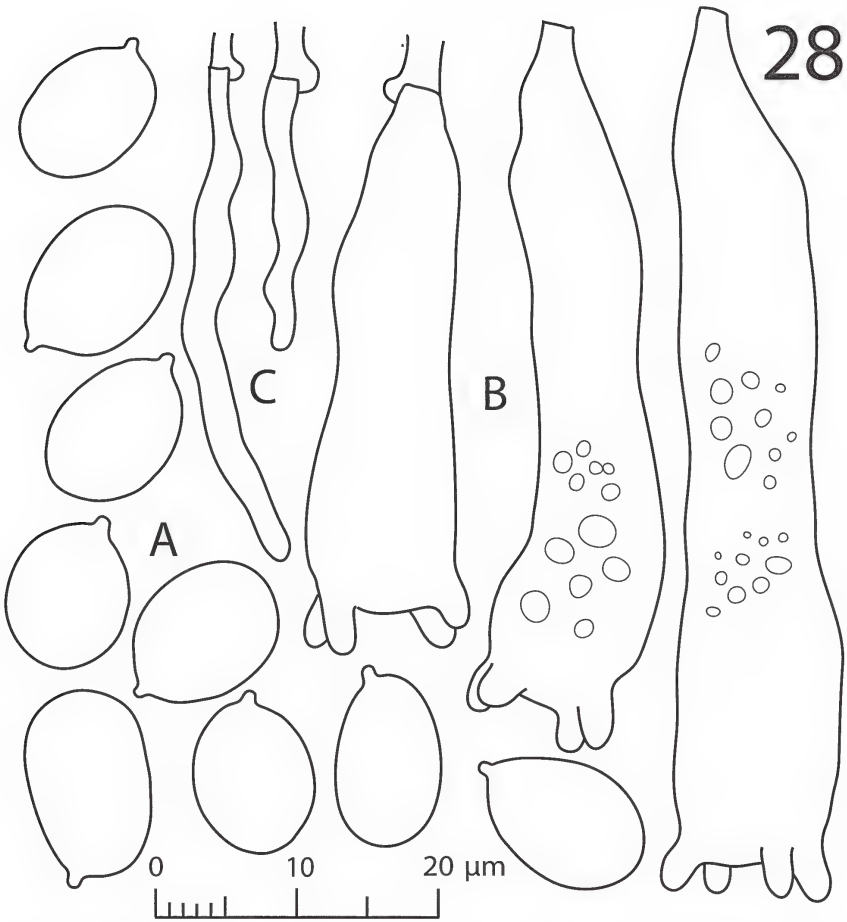



Fig. 28. ***Mycothele disciformis*** (isotype BPI 0261300). A. Basidiospores; B. basidia; c. hyphidia.

Habitat and distribution — On bark of living trunks of *Rhopalostylis sapida* H. Wendl. & Drude in New Zealand.

Type specimen examined — **NEW ZEALAND.** Auckland: Henderson Valley, 130 m., Sharps Bush, on bark of *R. sapida*, 5 May 1952, SD Baker PDD 11491 (BPI 261300, **isotype**). In the original description, the month is mistakenly reported as April (Cunningham 1956: 636).

Specimens examined — **NEW ZEALAND.** Auckland: Titirangi, Atkinson Park, on *R. sapida*, 27 Jun 1953, JM Dingley (PDD 12643); Coromandel Peninsula, Camel's Back, on *R. sapida*, Oct 1954, JM Dingley (PDD 14304); Waitakeres, Cascades, on *R. sapida*, 3 Apr 1954, SD Baker (PDD 14307).

Descriptions and illustrations — Cunningham (1956, 1963: 173), Jülich (1976).

Comments — *Mycothele disciformis* is characterized by small fragile disciform basidiomes with prominent hyphal pegs. *Epithele ryvardenii* Nakasone is an effused species that is reminiscent of *M. disciformis* because it produces brown-pigmented hyphae and has similarly sized and shaped basidia and basidiospores (Nakasone 2013). However, *M. disciformis* is found on bark of living nikau, an endemic New Zealand palm, whereas *E. ryvardenii* is reported from Venezuela on wood. *Mycothele disciformis* is undoubtedly closely related to *Epithele* (Pat.) Pat. Whether it should be transferred to *Epithele* or retained as a monotypic genus may be resolved in the future with molecular evidence.

*Mycobonia flava* (Sw. : Fr.) Pat., Bull. Soc. Mycol. France 10: 77. 1894. Figs 22, 29–30

≡ *Peziza flava* Sw. : Fr., Prod.: 150. 1788, non *Polyporus flavus* Jungh. 1838.

≡ *Hydnum flavum* (Sw. : Fr.) Berk., Ann. Mag. Nat. Hist., 10: 380. 1843 ["1842"].

≡ *Bonia flava* (Sw. : Fr.) Henn., Hedwigia 36: 192. 1897, as "(Berk.) Pat."

≡ *Auricularia flava* (Sw. : Fr.) Farl., Bibl. Index N. Amer. Fung.: 307. 1905.

≡ *Grandinioides flava* (Sw. : Fr.) Banker, Mem. Torrey Bot. Club 12: 179. 1906.

≡ *Polyporus curtipes* subsp. *flavus* (Sw. : Fr.) D. Krüger, Cryptog. Mycol. 31: 399. 2010.

≡ ***Polyporus epitheloides*** Nakasone, **nom. nov.**

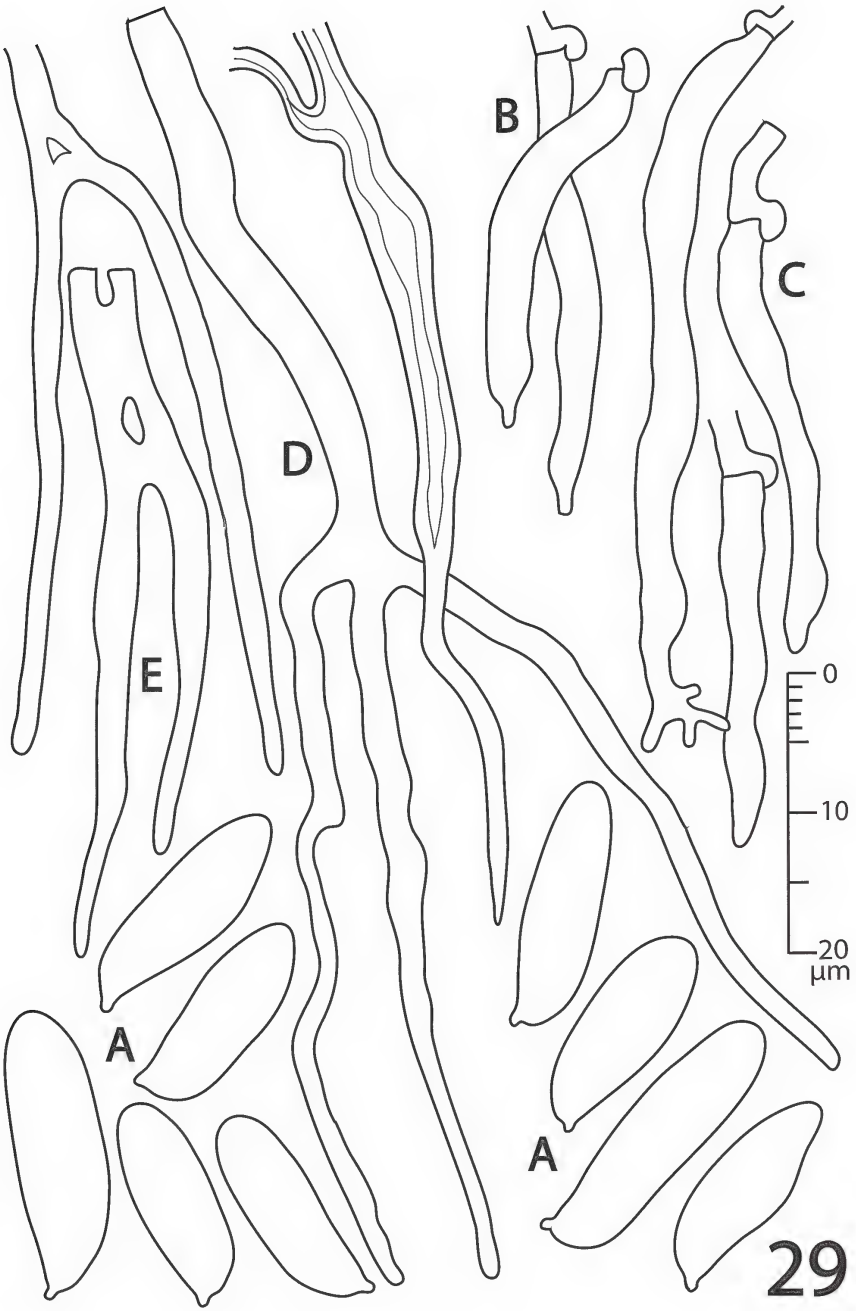
MycoBank MB812358

Etymology: refers to similarity with the genus *Epithele* which is characterized by hyphal pegs.

Basidiome pileate, dimidiate, flabelliform or reniform, sessile or substipitate, coriaceous. Pileus applanate, subdiscoid, or shallowly cucullate, ≤8 × 4 cm; upper surface smooth then becoming radially rugulose, when dried dull, pallid ochraceous, greyish orange (5B5) to brown [6D(7–8)] or purplish chestnut, darkening at edges to brown (6E8). Stipe short, ≤5 mm long by 3 mm diam, often black, attached to substrate by a thin, circular, mycelial pad, ≤8 mm diam. Context 1–6 mm thick at base, thinning to 0.5 mm at pileus edge, light orange (5A4), thin, coriaceous. Hymenial surface appearing smooth but densely covered with cylindrical hyphal pegs, ≤400 × 40–60 µm, 5–11 pegs per mm, pale ochraceous when fresh, drying to greyish orange (5B4), Light Ochraceous Buff, purplish buff, or light rusty buff.

Hyphal system dimitic with clamped generative and aseptate skeleto-binding hyphae. Hyphal pegs a dense fascicle of non-agglutinated, sparsely branched, skeleto-binding hyphae, originating in context, projecting ≤200 µm, heavily encrusted with coarse, irregular, hyaline crystals; hyphae 1–3 µm diam, aseptate, rarely branched, walls hyaline, slightly thick to thick, smooth, cyanophilous, weakly dextrinoid. Context a densely interwoven,

Fig. 29. ***Polyporus epitheloides*** (NY 00536421). A. Basidiospores; B. papillate hyphidia; C. thin-walled hyphidia; D. thick-walled hyphidia or skeleto-binding hyphae terminating in hymenium; E. cystidium.

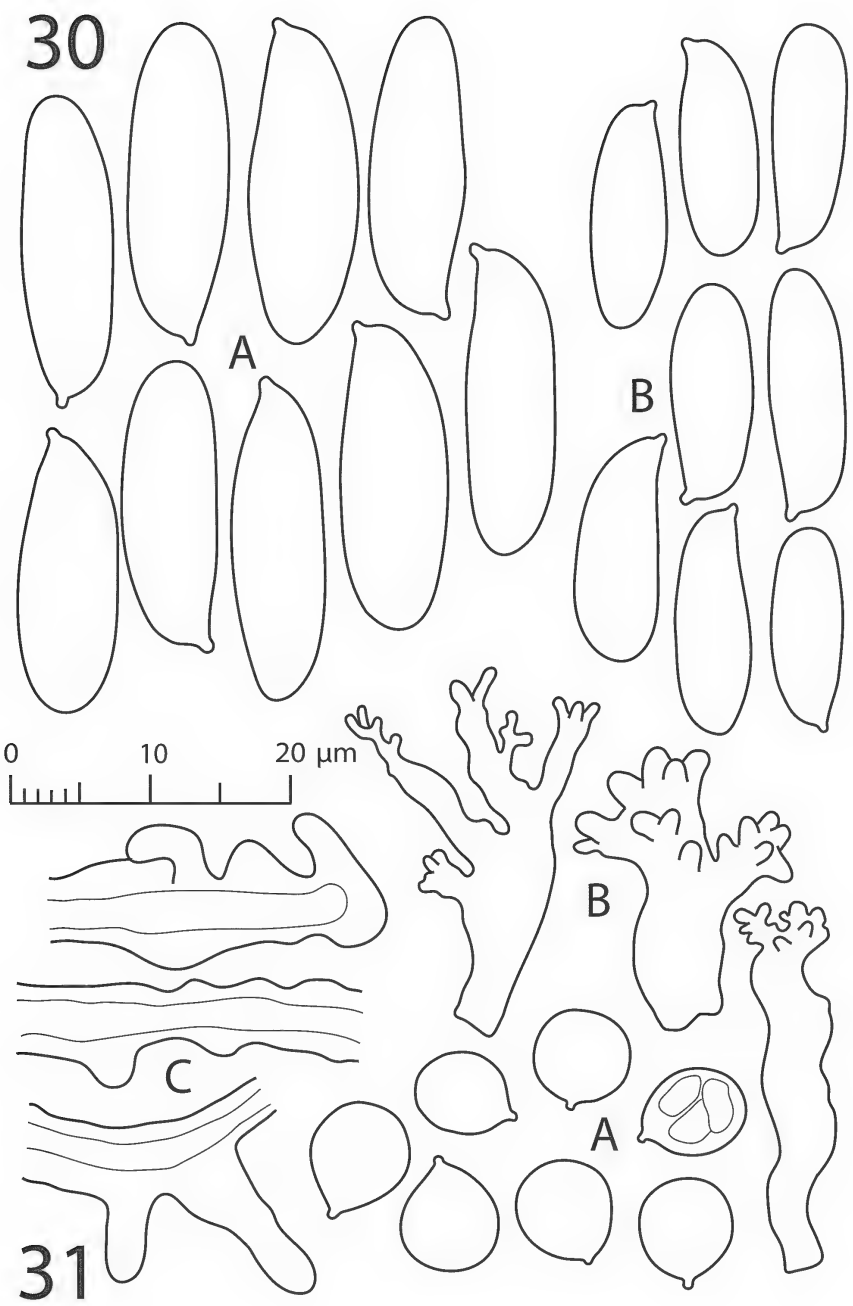

B
C
D
E
A
A
0
10
20
µm
29

non-agglutinated tissue composed primarily of skeleto-binding hyphae and indistinct generative hyphae, in pileus cuticle hyphae similar but compacted into a cutis; generative hyphae 2.2–4 µm diam, clamped, walls hyaline, thin, smooth; skeleto-binding hyphae 2.2–5 µm diam, occasionally inflated ≤20 µm diam, aseptate, rarely to extensively branched, branches often elongate and whip-like, walls hyaline, thick, smooth, acyanophilous, not reacting in Melzer's reagent. HYMENIUM a dense palisade of hyphidia, cystidia, and basidia. HYPHIDIA of two types: (a) inconspicuous, scarce, filamentous, often with a few short branches at apex or papillate, 27–52 × 2–4 µm, clamped at base, walls hyaline, thin, smooth; (b) numerous, acicular or narrowly cylindrical then tapering to a subacute to acute apex, 30–60 × 2–4 µm, aseptate, walls hyaline, slightly thick, smooth, acyanophilous, not reacting in Melzer's reagent (may be interpreted as terminal branches of skeleto-binding hyphae). CYSTIDIA rare, obclavate, an enlarged bulbous base then tapering to apex, 25–45 × (6–)10–15 µm, aseptate, walls hyaline, ≤1 µm thick, smooth, acyanophilous, not reacting in Melzer's reagent. BASIDIA clavate, 26–40 × 6–12 µm, clamped at base, walls hyaline, thin, smooth, with 4-sterigmata. BASIDIOSPORES cylindrical to subfusiform, 14–23(–26) × 5–8(–8.7) µm, average of three specimens 15.6–22.5 × 5.2–7.4 µm, Q = 3, filled with oil-like material, walls hyaline, thin, smooth, acyanophilous or weakly cyanophilous, not reacting in Melzer's reagent.

HABITAT & DISTRIBUTION — On logs, branches and twigs of dead angiosperms from southeastern United States (Florida, Louisiana) to southeastern Brazil.

REPRESENTATIVE SPECIMENS EXAMINED — **ARGENTINA**. MISIONES PROVINCE: Urugua-í Provincial Park, Wanda, 26 May 2001, D Krüger 11279 (TENN 59088). **BRAZIL**. RIO GRANDE DU SOL PROVINCE: São Leopoldo, 1904, Rick (S F–249620); Rick–Fungi Austro-Americano Exsiccati nr. 141, 1906 (S F–177427, F–177429); Ijuhy, Exped. Imae Regnelliana no. 345B, 7/4 1893, GA Malme (S F–177430). **COLOMBIA**. CAUCA DISTRICT: ad pag. El Tambo, 1700 m, 13 Nov 1937, Kv Snidern (S F–177424). Valle del Cauca Dept., elev. 1980 m., 23 km from Cali, on Cali-Cisneros, on branch, 30 Aug 1976, KP Dumont & LA Molina, Dumont–Co 7669 (NY). **COSTA RICA**. PUNTRENAS PROVINCE: Coto Brus County, San Vito, Hacienda La Amistad, 3 Jul 1998, RH Petersen 9486 (TENN 56514); Tablazo, 1800 m, 8 Aug 1932, M Valerio (S F–177432). CARTAGO PROVINCE: mountains east of Tulis and north of Plantanillo, 2 Sep 1968, DE Stone 7141 (NY 00536421). **CUBA**. Fungi Cubensis Wrightiani no. 343, [Wright] (S F–15535); Monte Verde, Fungi Cubensis Wrightiani no. 237, 7–4 1915, C Wright (S F–15533). PINAR DEL RIO PROVINCE: San Diego de Los Baños, on old log, 31 Aug to 3 Sep 1910, NL Britton, FS Earle & OS Gages, Britton 6823 (NY). **JAMAICA**. ST. ANN PARISH: near Reynolds bauxite mines, Lynford P.O., 1200–1400 ft., on dead branch of small tree, 23 Sep 1954, GR Proctor, F1288 (NY 00536418); Moneague to Hollymount via Union Hill, 700–750 m. elev., 6 Aug 1957, AL Welden 558 (NY 00536419). **PARAGUAY**. ALTO PARANÁ STATE: Ciudad del Este Hernandarias, Tatí Jupí Reserve on Iaipu Lake, on

FIGS 30–31. ***Polyporus epitheloides.*** 30. Basidiospores: A. from TENN 56514; B. from TENN 59088. ***Mycobonia winkleri*** (holotype F–15807). 31. A. Basidiospores; B. broom-like structures in pileus context; C. hyphal segments from pileus context.


30
A
B
0
10
20 µm
C
B
A
31

hardwood branch, 25 May 2001, RH Petersen (TENN 58933); San Antonio Province: Asunción, Exped. Imae Regnellian Fungi, July 1893, GA Malme (S F–177425). **UNITED STATES.** Florida: Florida Caverns State Park, on dead wood, 5 May 1962, AL Welden 4428 (NY 00536416); Miami, on twigs, 15 Jan 1919, WH Long (CFMR FP 30869); Dade County, Matheson's Hammock, on twigs, 23 Feb 1922, JA Stevenson 1630 (BPI 261319). Louisiana: Plaquemines Parish, Tulane University, F. Edward Herbert Center, on dead wood, 25 Jul 1972, AL Welden 7764 (NY 00536411); St. Martinville, on fallen branches, 20 Aug 1898, AB Langlois 2817 (S F–249626).

Descriptions & illustrations — Burt (1919: 262), Corner (1984: 104), Jülich (1976: 450, description only), Patouillard (1894, plate III, fig. 2), Reid (1976: 190, figs 1, 5), Ryvarden (2010: 119).

Comments — *Polyporus epitheloides* is a pileate species characterized by a dense layer of hyphal pegs in the hymenium and large cylindric to subfusiform basidiospores. The peculiar thick-walled cystidia seen in this species were also observed in *P. polyacanthophorus* and could be interpreted as terminally differentiated skeleto-binding hyphae. Jülich (1976: 451) refers to these structures as tramal cystidia and includes an illustration. The description above is based on Jülich (1976), Reid (1976), and personal observations. Transfer of the species to *Polyporus* requires a new name because the epithet '*flavus*' is preoccupied.

*Polyporus epitheloides* is closely related to *P. polyacanthophorus* [≡ *M. brunneoleuca*] but can be differentiated by its narrowly cylindrical to subfusiform basidiospores that are usually <8 µm diam, Q = 3. *Polyporus epitheloides* has a wider distribution than *P. polyacanthophorus*, extending into southeastern United States. ITS sequences of *P. epitheloides* (AY513571 as *M. flava*) and *P. polyacanthophorus* (AY513569, AY513570 also as *M. flava*) differ by 5%, confirming their status as distinct species. Another similar species is *Pseudofavolus cucullatus* (Mont.) Pat. [= *Polyporus curtipes*]. It can be distinguished from *P. epitheloides* by its angular to hexagonal pores, 1–3 per mm, and smaller, cylindrical basidiospores (11.5–)13–16 × 4–6 µm (Ryvarden & Johansen 1980: 514). The isotype of *Favolus curtipes* Berk. & M.A. Curtis (South Carolina, Santee, Ravenel 378, HUH 00290582) was examined (see Figs. 19–20 for photographs of the poroid hymenophore).

Krüger (2002) and Krüger & Gargas (2010) considered *M. flava* to be a subspecies of *P. curtipes* despite a 4–7% difference in ITS sequences. They noted that *M. flava,* with spines, and *Ps. cucullatus*, with pores, were otherwise similar in basidiome coloration, hyphal construction, and shape and size of basidia and basidiospores. Because they are sister taxa embedded in *Polyporus* sensu stricto as demonstrated by phylogenetic analyses of the large subunit ribosomal RNA gene and ITS region, Krüger (2002) and Krüger & Gargas (2010) concluded that *M. flava* and *Ps. cucullatus* belong in *Polyporus*. Following Ryvarden (1991:

213), they accepted the name *P. curtipes* for *Ps. cucullatus* and then reduced *M. flava* to a subspecies of *P. curtipes*.

It should be noted that Krüger (2002) and Krüger & Gargas (2010) misidentified TENN 057579, FB 10256, as *M. flava*. Based on basidiospore size, this specimen represents *P. polyacanthophorus* [≡ *M. brunneoleuca*]. Thus, ITS (AY513569, AY513570) and LSU sequences (AJ487934) correspond to *P. polyacanthophorus* whereas AY513571, ITS sequence of TENN 059088, FB 11279, is correctly identified as *P. epitheloides* [≡ *M. flava*].

The following descriptions and illustrations should be used with caution, for the authors did not differentiate between *M. flava* and *M. brunneoleuca* or did not provide basidiospore measurements, so it is not possible determine the species involved — Banker (1906), Berkeley (1843, plate 10, fig. 8), Gibertoni et al. (2006), Hennings (1900), Ibañez (1999), and Lloyd (1915). Although Martin (1939: 247) considered *M. brunneoleuca* a synonym of *M. flava*, the specimens he cited from Panama are redetermined here as *P. polyacanthophorus*.

*Mycobonia winkleri* Bres., Ann. Mycol. 9: 551. 1911. FIGS 23–24, 31

BASIDIOME dimidiate-sessile to subresupinate, 17 × 7 mm, 320–400 µm thick, soft, fragile, greyish orange (5B4). PILEUS SURFACE warty to wrinkled; HYMENIAL SURFACE smooth with warts, 2–3 per mm, with a dark cavity or reddish brown, mucilaginous material at apex; context cottony, orange white (5A2).

HYPHAL SYSTEM dimitic with clamped generative and aseptate skeletal hyphae. WARTS consisting of bulbils embedded in context and hymenium, composed of pseudoparenchymatous tissue enclosing a mass of dark reddish brown, amorphous material. PILEUS CORTEX a densely agglutinated tissue composed of irregularly thick-walled hyphae, thick-walled, broom-like structures, and scattered dichophyses; pileal hyphae 3–8 µm diam, clamped, with numerous short branches, irregular, walls hyaline, thick, smooth; broom-like structures 17–30 × 3–8 µm, with a thick, robust main trunk that gives rise to branches short and stubby or longer, ≤12 × 2 µm, with knobby protuberances, walls hyaline, thick, smooth, cyanophilous, not reacting in Melzer's reagent; dichophyses with short, slender branches radiating from a central point, walls hyaline, thick, smooth, cyanophilous, dextrinoid. Beneath cortex a narrow, moderately dense zone of generative subicular and skeletal hyphae, then a zone of open, loosely intertwined subicular hyphae and scattered dichophyses, about 140 µm thick; subicular hyphae 3–5 µm diam, clamped, moderately branched, walls hyaline, thin to 2 µm thick, sometimes irregularly thickened, smooth, acyanophilous, not reacting in Melzer's reagent; skeletal hyphae 1.3–2.2 µm

diam, aseptate, sparsely branched, walls hyaline, thick, smooth, cyanophilous, dextrinoid in Melzer's reagent. Subhymenium a dense, agglutinate tissue of hyphae similar to subicular hyphae. Hymenium a dense, agglutinated palisade of basidia. Basidia clavate, 25–28 × 12 µm, bisterigmate (Bresadola, 1911). Basidiospores scarce, globose, subglobose or broadly lacrymoid, 6–7.5(–7.9) × (5.5–)6–7.2 µm, walls hyaline, thin, smooth, cyanophilous, not reacting in Melzer's reagent.

Type specimen examined — S.O. **BORNEO**, ad *Calamus rotang*, 24 Jun 1902, H Winkler 2605 (S F–15807, **holotype**).

Comments — *Mycobonia winkleri* is a conundrum. The fungus displays a bewildering array of morphological features and the name cannot be placed in any extant genus. In the first place, the unusual structures that resemble hyphal pegs in *M. winkleri* (and probably the reason Bresadola placed the species in *Mycobonia*) are not composed of hyphae but consist of an amorphous reddish brown material. Second, the cyanophilous dextrinoid dichohyphidia developed in *M. winkleri* resemble those found in some species of *Vararia* P. Karst., such as *V. minidichophysa* Boidin & Lanq., *V. microphysa* Boidin & Lanq., and *V. tropica* A.L. Welden. Boidin et al. (1980) described these structures as capillary dichophyses. Two species of *Amyloflagellula* Singer, *A. verrucosa* Agerer & Boidin and *A. inflata* Agerer & Boidin, also develop similar dichohyphidia (Agerer & Boidin 1981). Third, the broom-like structures found in the pileus cortex recall those produced in the pileipellis and gills of some *Marasmius* Fr. species. However, the rather large, dimidiate-sessile basidiome of *M. winkleri* is unlike that of *Vararia* (effused), *Amyloflagellula* (cup-shaped), or *Marasmius* (mushroom-shaped).

It is premature to erect a new genus for *M. winkleri* at this time. The type is fragile and somewhat deteriorated. Additional collections are needed to confirm that the disparate characters are produced by this taxon. The hyphal peg-like structures are particularly mysterious and in need of further study. DNA sequence data would be desirable to discover its closest relatives.

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# A new *Graphilbum* species from western hemlock (*Tsuga heterophylla*) in Canada

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Abstract — A new species of *Graphilbum*, *G. tsugae* isolated from *Tsuga heterophylla*, is described from British Columbia, Canada. Although rDNA ITS data analysis demonstrates its close relationship to *Graphilbum rectangulisporium,* morphologically the unique apical projections arising from the perithecial necks of *G. tsugae* easily differentiate it from the former and all other described *Graphilbum* and *Ophiostoma* species. We also correct the epithet orthography and the parenthetical basionym author citation of the name *G. rectangulisporium.*

Key words — ophiostomatoid fungi, bark beetles, morphology, taxonomy, ITS rDNA region.

## Introduction

During a reassessment of isolates of ophiostomatoid fungi in our culture collection whose taxonomic placements had never been resolved, we examined three strains from a single location in southern British Columbia isolated from two felled logs of *Tsuga heterophylla*. These logs had shown clear evidence of having been attacked by bark beetles — many bore holes were evident and peeling back the bark around the holes revealed well-developed galleries — but neither beetle adults nor larvae were present and the surrounding sapwood was only slightly stained. However, hand lens examination did show both remnant hyphae and possible reproductive structures scattered throughout gallery interiors.

Slabs of bark-covered wood about 12 inches long, 6–8 inches wide, and 1–3 inches thick were harvested from such areas using a hatchet and a chisel. The bark was then removed to expose the outer sapwood surfaces and the inner bark surfaces of these slabs. After the wood slabs and bark pieces were examined carefully to ensure no adult beetles or larvae were present in any of the exposed galleries, these materials were placed and sealed in collection bags for return to the laboratory.

When we began our detailed study of this species, the *Ophiostomatales* accommodated three genera: *Ceratocystiopsis* H.P. Upadhyay & W.B. Kendr.; *Grosmannia* Goid.; and *Ophiostoma* Syd. & P. Syd., among which species economically important tree pathogens and blue-stain fungi are found (Olchowecki & Reid 1974, Wingfield et al. 1993, Hausner et al. 2005).

Based on partial LSU rDNA and β-tubulin sequences, Zipfel et al. (2006) provided some support for the circumscription of the above three genera. But Zipfel et al. (2006, p. 95) and other authors (Hafez et al. 2012, 2013) also noted that the use of molecular criteria might require the erection of new genera to accommodate either previously misplaced or subsequently newly discovered species of *Ophiostoma* sensu lato.

Recently de Beer & Wingfield (2013), using partial LSU and SSU rDNA sequences, have begun redefining the *Ophiostomatales*. They include only one family, the *Ophiostomataceae*, in which they recognize six distinct lineages represented by the genera *Ceratocystiopsis* H.P. Upadhyay & W.B. Kendr. emend. Zipfel et al. (2006), *Fragosphaeria* Shear, *Leptographium* Lagerb. & Melin sensu lato (includes *Grosmannia*), *Ophiostoma* sensu lato (includes *Pesotum* and *Sporothrix)*, *Raffaelea* Arx & Hennebert emend. T.C. Harr. in Harrington et al. (2008), and *Graphilbum* H.P. Upadhyay & W.B. Kendr. emend. Z.W. de Beer et al. (2013a). They also clearly implied the possible need for further generic inclusions. Relevant comments are also found in related accompanying papers (de Beer et al. 2013a & b).

The genera of the *Ophiostomataceae* include economically important tree pathogens and blue-stain fungi (e.g., Lagerberg et al. 1927, Olchowecki & Reid 1974, Wingfield et al. 1993, Hausner et al. 2005) whose members lack forcible ascospore discharge, have deliquescent asci, develop sticky ascospore droplets at the apex of their perithecial necks, and typically produce slimy/sticky conidia on various simple or complex conidiophore structures. Species assigned to *Ceratocystiopsis* resemble those of *Ophiostoma* except in *Ceratocystiopsis* the small dark perithecia only develop short perithecial necks and produce falcate, sheathed ascospores (Upadhyay 1981, Zipfel et al. 2006, Plattner et al. 2009). These species also have a lower tolerance to cycloheximide than do *Ophiostoma* species (Harrington 1981, Hausner et al. 1993). Species formerly assigned to *Grosmannia* (above) were distinguished by the fact they have *Leptographium* states.

As we could not definitively establish the identity of our three isolates using only morphological criteria, we compared nuclear small subunit rDNA (rSSU) and rDNA internal transcribed spacer (ITS) region (ITS1, 5.8S gene, and ITS2) sequences from our isolates with those of other *Ophiostoma* species. We also assessed the growth rates and cultural characteristics of our isolates at different

temperatures and compared our results with data published for other species. We did not assess mating type features, as we had earlier when describing another ophiostomatoid species (Reid et al. 2010), as mating type studies had not been conducted for any of the species with which we compared our current isolates.

Based on the revisions discussed above, we believe our results show that our isolates represent a new taxon within the genus *Graphilbum* that we describe here as *Graphilbum tsugae*.

## Materials & methods

### Isolation of strains studied, culturing procedures, and growth-temperature experiment

Laboratory isolations were made from field collected wood and bark samples and grown on agar plates in a 20°C incubator; these were examined periodically for evidence of fungi of interest.

We obtained three isolates that, based solely on morphological criteria, appeared to represent an undescribed *Ophiostoma* species. Strains examined and/or sequenced are detailed in Table 1. Living cultures and dried specimens of our new species have been deposited in the University of Alberta Microfungus Collection and Herbarium (UAMH), Edmonton, Canada; the additional DNA sequences retrieved from GenBank employed in the analyses are also listed in Table 1.

Based on the intent of the experiment, strains were grown and characterized employing either malt extract agar supplemented solely with yeast extract (Reid et al. 2010) or such agar that also contained wood chips (Reid & Hausner 2010); fertile perithecia were regularly produced on the latter plates. These were then dried, and one was selected to be the type specimen. The parent culture was isolate WIN(M) 1391, obtained from a perithecial spore drop produced at the apex of a perithecium found in the gallery of an unidentified bark beetle. Preparations for microscopy were mounted in 85% lactic acid and at least 50 measurements were made for each significant morphological feature. Colour designations are based on Rayner (1970).

In a previous study (Reid et al. 2010) where we had found a group of very similar isolates growing on pieces of substrate in very close proximity to each other — as was the case here — we had processed three of them in a temperature growth-rate response experiment, and they produced very similar growth-temperature files. They and the other isolates in the group were described as *Ceratocystis norvegica* J. Reid & Hausner [sic; = Georg Hausner].

Because of that experience, the precise identity of the gene regions sequenced in our current three isolates, and the lack of any significant morphological variation noted between them, we used only the designated holotype isolate, UAMH 11701 [WIN(M) 1391] for determining the temperature growth-rate response of *G. tsugae*.

We employed the protocols of van Wyk et al. (2006), as modified by Reid et al. (2010). However, because of the cultures' relatively slow growth, the first measurements were not made until the second day after plate inoculation. We used eight replicate plates at each test temperature. Although initially, the total temperature-growth test

Table 1. The rDNA ITS region sequences evaluated

| Taxon | Strains/Isolates/source[1] | GenBank |
|---|---|---|
| *Ceratocystiopsis minuta* | [2]CBS 145.59 | DQ128173 |
| *C.* cf. *minuta* | SL-K 70 | DQ128175 |
| *Grosmannia penicillata* | RJ-T 0125 | AM943882 |
| *Ophiostoma abietinum* | CMW 397 | DQ396788 |
| *O. dentifundus* | CMW 13016 [a] | AY495434 |
| | CMW 13017 [a] | AY495435 |
| *O. ips* | CMW 22843 | DQ539549 |
| *O. grandicarpum* | Strain D | AJ293884 |
| *O. microcarpum* | YCC 459 | AB506676 |
| | YCC 612 | GU134170 |
| *O. piceae* | Ci-37 | EF506934 |
| *O. pulvinisporum* | CMW 9026 | AY546715 |
| *O. rectangulisporium* | TFM:FPH 7756 | AB242825 |
| | YCC 617 | GU134171 |
| *O.* cf. *rectangulisporium* | CMW 26261 [b] | EU785451 |
| | CMW 26259 [b] | EU785450 |
| | CMW 26258 [b] | EU785449 |
| | C2477 | GU129987 |
| | C2300 | GU393357 |
| | 253GRJ [c] | JX444645 |
| | 1313RJP [c] | JX444594 |
| | 1039RJP [c] | JX444590 |
| | 1037RJP [c] | JX444589 |
| | 1284RJP [c] | JX444591 |
| | 1308RJP [c] | JX444593 |
| | 1306RJP [c] | JX444592 |
| | 246bGRJ | JX444644 |
| | CMW 22830 [d] | DQ539536 |
| | CMW 22829 [d] | DQ539535 |
| | CMW 22832 [d] | DQ539538 |
| | CMW 22831 [d] | DQ539537 |
| | 1132RJ [d] (=voucher 1138RJ) | JQ289021 |
| *O. rostrocoronatum* | CBS 434.77 | AY194509 |
| *Graphilbum tsugae* | WIN(M) 1391 [e] (=UAMH 11701) | KJ661745 |
| | WIN(M) 1384 [e] (=UAMH 11700) | — |
| | WIN(M) 1387 [e] (=UAMH 11699) | — |
| *Ophiostoma* sp.1 | WIN(M) 1602 | HM363177 |
| | WIN(M) 1603 | HM363164 |
| *Ophiostoma* sp. 2 | RJ-0771 [f] | AM943895 |
| | RJ-0704 [f] | AM943894 |
| *Ophiostoma* sp. 3 | PR-2006c (=CMW 27315) | DQ674367 |

| | | |
|---|---|---|
| *Pesotum fragrans* | CMW 22853 | DQ539561 |
| | C01-014a [g] | AY194513 |
| | NLC 348 [g] | AY194518 |
| | CBS 279.54 [g] (=C1224) | AF198248 |
| | WIN(M) 1388 [g] | — |
| | C990 | DQ062976 |
| *P cupulatum* | C1194 | AF198230 |
| *Sporothrix inflata* | CMW 12529 | AY495428 |

[1]Strain numbers followed by identical superscript letters ([a] to [g]) have identical ITS regions and only one representative was used in the ITS phylogenetic analysis.

[2]CBS = CBS-KNAW Fungal Biodiversity Center, Utrecht, Netherlands; WIN(M) = culture collection of J. Reid, Microbiology, University of Manitoba, Winnipeg, Manitoba, Canada; UAMH = University of Alberta Microfungus Collection and Herbarium, Devonian Botanic Garden, Edmonton, Alberta, Canada; CMW, Tree Pathology Co-operative Program, Forestry and Agricultural Biotechnology Institute, University of Pretoria, South Africa; STE-U, Stellenbosch University, South Africa.

period was to have lasted seven days, we incubated all plates further at 20°C to record morphological development.

### DNA extraction, amplification protocols and DNA sequencing

DNA extraction, purification, and agarose electrophoresis protocols followed Hausner et al. (1992). Genomic DNA served as the amplification template using the Invitrogen-Life Technologies PCR System (Buffer and Taq polymerase, Invitrogen, Fredrick, MD). Primers SSUZ and LSU4 (Hausner et al. 2005) were used to amplify the ITS regions. The PCR primer sequences, amplification conditions, sizes of the expected PCR products, and preparation of sequencing templates for fragments have been described previously (Hausner & Wang 2005, Hausner et al. 2005). DNA sequencing templates were prepared with the aid of the Promega Wizard SV Gel and PCR clean-up system (Promega, Madison, WI). Purified double-stranded PCR products were sequenced in both directions using the cycle-sequencing protocols performed according to the manufacturer's recommendations (Perkin Elmer Applied Biosystems, Foster City, CA), and automated Fluorescent DNA sequence analysis was performed using an ABI Prism 310 Genetic Analyzer system (PEAB at the University of Calgary, DNA sequencing facility, Calgary, AB).

### Analyses of DNA sequence data

To add to sequences generated herein, we used the UAMH 11701 ITS sequence in a BLAST search to recover additional sequences from NCBI databases for comparison with other relevant taxa. Fifty ITS rDNA sequences were aligned with CLUSTAL-X (Thomson et al. 1997) and, when appropriate, modified with the alignment editor program GeneDoc v2.5.010 (Nicholas et al. 1997, http://www.psc.edu/biomed/genedoc). Phylogenetic trees were generated using the Molecular Evolutionary Genetic Analysis program package (MEGA 5.1; Tamura et al. 2011). Trees were generated with the Maximum parsimony (MP), Neighbor joining (NJ), and Maximum likelihood (ML) methods. MEGA 5.1 was also used for determining the best-fit DNA models and the best-fit substitution model for ML analysis. In order to evaluate node support within the

tree topologies, the bootstrap option (1000 replicates) was selected for all tree-building programs.

Finally, MrBayes (version 3.1; Ronquist & Huelsenbeck 2003) was used for Bayesian analysis. The NEXUS file format necessary for the alignment (input) file was generated with the file converting option available within DAMBE (Xia 2001). The DNA substitution model setting for Bayesian analysis was chosen based on evaluating the ITS region alignment with the Modeltest 3.7 program (Posada & Crandall 1998). The Bayesian inference of phylogenies was initiated from a random starting tree, and four chains were run simultaneously for 3 million generations; trees were sampled every 100 generations. The first 25% of trees generated were discarded (burn-in); the remaining trees were used to construct a 50 % majority rule consensus tree and compute the posterior probability values.

Phylogenetic trees were drawn with the TreeView program (Page 1996) and figure annotations added using Corel Draw (Corel Corporation and Corel Corporation Limited).

## Results

### Cultural and morphological characteristics

The temperature-related growth response of isolate UAMH 11701 (Fig. 1) depicts a relatively broad growth temperature optimum, i.e. 20–25°C, dropping off sharply towards both 15 and 30°C. The mycelium amount produced differed between test temperatures but was always appressed, with only limited sparse, central aerial mycelium. During the first 7 days, the mycelium remained hyaline (translucent) and without coloration or reproductive structure development.

All eight plate sets from the various test temperatures were then placed in a single 20°C incubator.

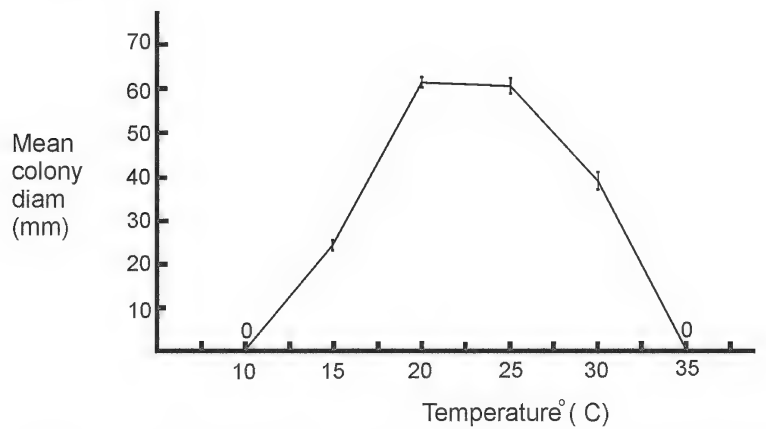



Fig. 1: Temperature-growth curve for *Graphilbum tsugae* holotype strain UAMH 11701 incubated at various temperatures for 7 days.

By day10, mycelium in all original 20°C and 25°C cultures had reached Petri dish margins. It was still mostly hyaline and appressed, but with a ring of slightly more floccose white-colored mycelium around the paler center (Fig. 2A); these cultures were virtually identical in growth rates and appearance.

The 15°C and 30°C cultures had also grown further; their diameters were still quite small, but the 10°C and 35°C cultures showed only numerous short hyphae extending from their inoculation discs; apparently the fungus could survive a short exposure to the relatively high 35°C temperature.

All plate sets were then returned to the 20°C incubator until day 17.

In all original 20°C cultures, the mycelium had completely covered the dish surfaces. It was still quite peripherally appressed, more floccose centrally, and while still primarily white, there were definite scattered amber tints and a central darkening (Fig. 2B). Very occasionally scattered immature differentiating perithecia were observed, but only a few showed what might have been developing neck initials.

On day 17 in the original 25°C cultures, the mycelium had also reached dish margins. Generally it was still white, but now there were scattered slight amber tints. Less aerial mycelium was present peripherally than centrally, but that difference was now less pronounced. Overall there was less aerial mycelium than in the 20°C plates, but the central dark (Fuscous Black) pigmentation (Fig. 2C) was more pronounced and perithecial development more advanced. In six dishes the perithecia were quite numerous but fewer in the remaining two, suggesting that 25°C may be slightly better for perithecial production.

On day 17 in the original 10°C cultures, all isolates were growing, but no mycelium had reached a dish margin. Colony diameters averaged 70 mm, the mycelium was white and peripherally appressed to slightly floccose centrally, but no perithecial initials were present. In the original 15°C cultures, mycelium, which reached the dish margins randomly, was white, appressed peripherally, and slightly floccose centrally.

On day 17 in the original 30°C cultures, mycelium had reached the dish margins uniformly, but again the amounts of central and peripheral mycelium differed markedly. The peripheral mycelium was white and appressed while the central mycelium was more floccose and showing numerous presumptive perithecium initials. And while all original 35°C cultures were growing, no mycelium had reached a dish margin. Colony diameters averaged 53 mm, and in every case the mycelium was white, appressed peripherally and more floccose centrally, and there was no evidence of perithecia.

After inspection, we retained only the original 20°C and 25°C cultures, which were thereafter both maintained at 20°C.

By day 24, these retained cultures were similar in appearance. New mycelium was less dense, older mycelium had collapsed centrally, and scattered amber

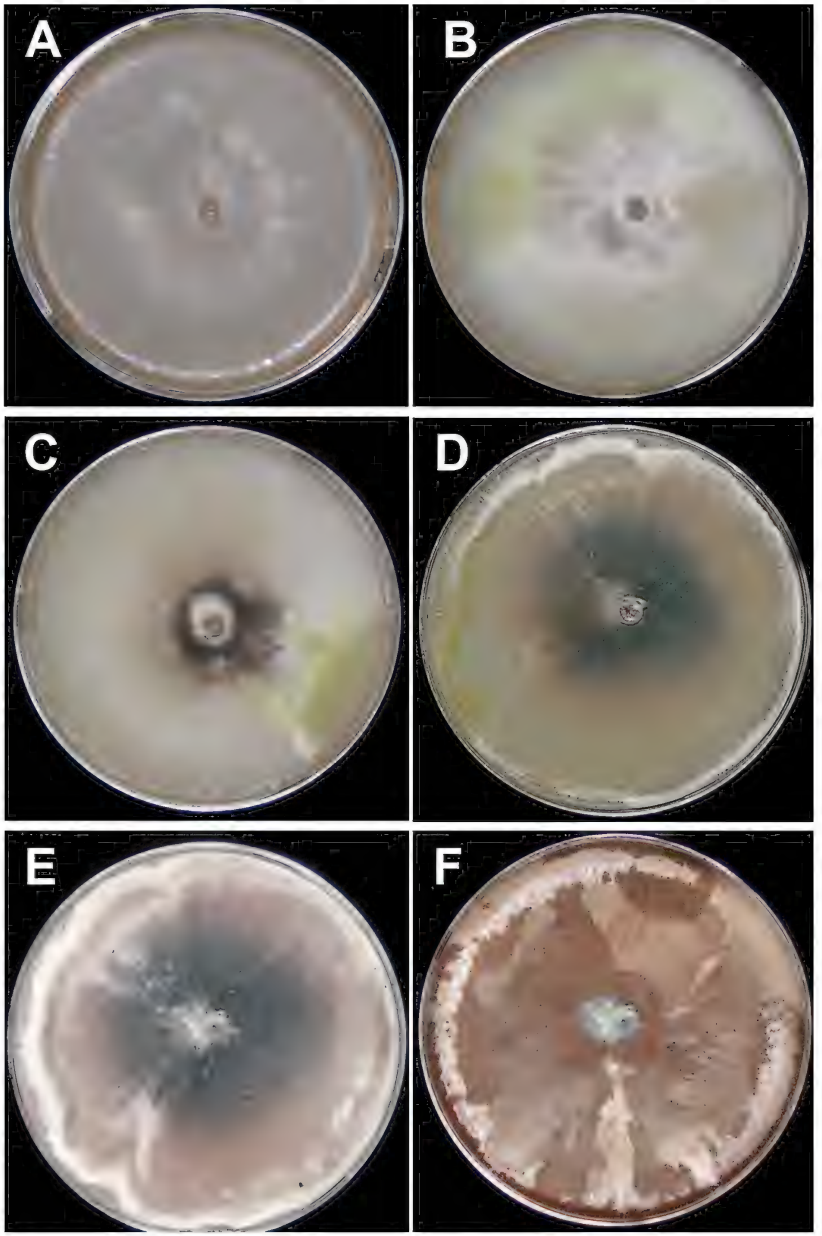



FIG. 2. *Graphilbum tsugae* (holotype, UAMH 11701 [WIN(M) 1391]). Morphology after growth at various temperatures. A. Original 20 °C plate at day 10. B. Original 20 °C plate at day 17. C. Original 25 °C plate at day 17. D. Original 25 °C plate at day 24. E. Original 25 °C plate after c. 7 weeks; F. Original 20 °C plate after c. 7 weeks.

colored patches, which were more common, often had turned pale yellowish-brown. More dark pigment was present centrally in the agar, and mounds of floccose white hyphae had formed at the colony margins. Although many perithecial initials were seen, no mature perithecia were found (Fig. 2D, an original 25°C culture).

Fig. 2E illustrates changes that occurred in an original 25°C culture over a further period of approximately 6–8 weeks. Note the increased amount of marginal mounded mycelium, increased area of central dark pigmentation, slight further overgrowth of superficial aerial mycelium, and finally, what appear to be abundant immature perithecia. Fig. 2F shows an even older original 20°C culture with extensive development of — now collapsed — marginal mounded mycelium but no apparent superficial mycelial overgrowth; there was also a restricted central dark pigmentation. Numerous perithecia were produced, but we only rarely saw any evidence of sporulation. Figs. 2E–F both show an extensive development of cinnamon-colored pigment throughout.

Because we rarely observed fully mature perithecia exuding spore droplets on agar dishes, we grew the strains on agar plus wood chips where mature perithecia were readily produced and their nature could be fully characterized (see Table 2 and Taxonomy section).

Table 2. Morphological comparisons between *G. rectangulisporium* and *G. tsugae*

| Character | *Graphilbum rectangulisporium* [a] | *Graphilbum tsugae* |
|---|---|---|
| Perithecial base | | |
| Shape | Globose | Obpyriform, ampulliform or globose [b]; |
| Width (µm) | 70-110 | 75-120(-167.5) |
| Height (µm) | 70-110 | 75 -113(-140) |
| Perithecial necks | | |
| Length (µm) | 190-500 including ostiolar hyphae | (87-)138-200(-280) including ostiolar hyphae |
| Base width (µm) | 20-35 | 27.5-50 |
| Tip width (µm) | 10-19 | 12.5-25 |
| Ostiolar hyphae | | |
| Length (µm) | 13–43 | (20-)25-40 |
| Number | 5-15 | Various |
| Shape (µm) | Cylindrical with apical taper | Crooked to jagged in outline; at times irregularly cellular; tapering to a point. |
| Ascospores (µm) | 2.0-3.5 × 1.0-1.7 with sheath; rectangular in side and face view | 3-5 × 1 with sheath; oblong to rectangular; sheath flaring at corners |
| Anamorph | None found | Conidiophores simple to branched; not identifiable to genus; Conidia hyaline, 1-celled, oblong, 2-5 × 1-1.5 µm. |
| Colony color | White; remaining so on 2% MEA | White initially, coloring (pale yellowish brown) on aging on 2% MEA + 1% YE[c] |

[a]Ohtaka et al. 2006; [b]Kirk et al. 2008; [c]Reid et al. 2010.

**DNA sequence analysis**

The rDNA SSU sequence (GenBank accession: HQ634824) for isolate UAMH 11701 — then as WIN(M) 1391 — was previously included in a study examining rDNA SSU intron distributions among ophiostomatoid fungi and related taxa (Hafez et al. 2012; p. 102). It showed that although UAMH 11701 was part of the *Ophiostomataceae* clade, it did not group with representatives of *Grosmannia*, *Ceratocystiopsis* or *Ophiostoma* sensu stricto. Instead, within the phylogenetic tree it assumed the most basal position among the sampled *Ophiostomataceae* taxa.

Our rDNA sequence analysis of the internal transcribed spacer (ITS) region (ITS1, 5.8S, and ITS2; KJ661745) yielded even more surprising results. Using this sequence set from isolate UAMH 11701 — again as WIN(M) 1391— in a BLASTN analysis, revealed that its sequences are similar to those from this

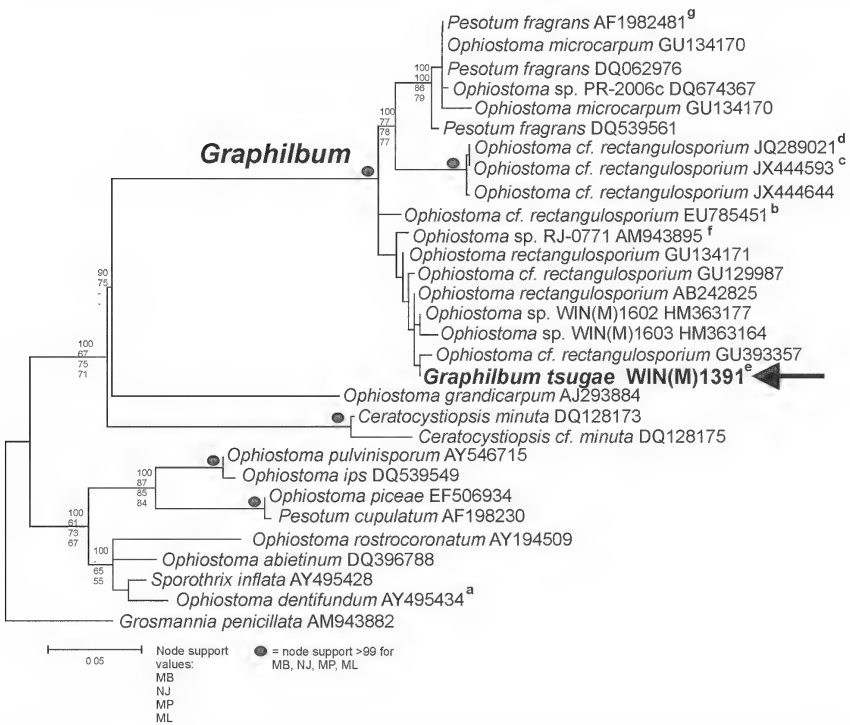



FIG. 3: Phylogenetic tree based on ITS sequence data. Levels of confidence for the major nodes in the phylogenetic tree are based on posterior probability (PP) values (MrBayes; first value), and bootstrap support (BS) in NEIGHBOR (second value), DNAPARS (third value), and Maximum likelihood analysis (fourth value). Nodes that received less than 50% support (BS or PP) were collapsed. Tree topology and branch lengths are based on Bayesian analysis and are proportional to the number of substitutions per site. GenBank accession numbers are listed next to species names.

region in strains identified as *Pesotum fragrans*, *Ophiostoma rectangulisporium*, *Ophiostoma* cf. *rectangulisporium*, and *O. microcarpum* (Fig. 3, Table 1). Comparisons within this ITS data set also strongly suggest that there are several yet to be described cryptic species within this clade. In particular the circumscription of *O. rectangulisporium* and isolates designated as *O.* cf. *rectangulisporium* need to be reevaluated, as the molecular data obtained failed to group these taxa into an appropriate clade relative to their assigned names. All these species are currently expected to be treated as members of the now holomorph genus *Graphilbum* (see below), whose species form a monophyletic group apart from species of *Ophiostoma* sensu stricto.

### Taxonomy

***Graphilbum tsugae*** J. Reid & Georg Hausner **sp. nov.** Figs. 4-7

MycoBank MB809811

Differs from all previously described species of *Graphilbum* by its apical ostiolar projections being not true ostiolar hyphae but elongated tapering neck cells with jagged outlines, its rDNA sequences, and its variably solitary or sporodochial anamorphic conidiophores.

Type: Canada, British Columbia, Highway 1, Annis Mountain, near Salmon Arm, from a felled log of *Tsuga heterophylla* (Raf.) Sarg., isolated from spore drop at apex of a perithecium in unidentified bark beetle gallery, 21 September 1987, collected and isolated by J. Reid. (**Holotype**, UAMH 11701 [dried culture on agar plus wood chips], derived from herein designated isotype culture WIN(M) 1391.

Etymology: *tsugae*, referring to the host genus *Tsuga*.

Maximum growth occurring on 2% malt-extract agar amended with yeast extract over a temperature range from 20°C to 25°C; maximum diameter 60 mm after seven days, i.e., relatively slow growing. No measurable growth at 10°C and below or 35°C and above. Colonies remaining only white over this period.

Anamorph apparently pleomorphic on wood chip agar plates. Some conidia developing terminally on short, simple, non-branched to slightly branched conidiophores. Others on variously branched conidiophore clusters that do not develop in any consistent branching pattern. Some are initially hyaline and verticillate, but later secondary cymose branches develop (see Seifert et al. 2011, fig. 100D) arising from beneath a septum in the parent branch. In others, branches that have arisen initially from a common point continue to branch along their length in a cymose fashion. Often these variously branched forms aggregate in clusters on the substrate, and then appear superficially as sporodochia until mounted. Conidiogenous cells proliferating in an imprecisely determined manner, as at times either sympodial or percurrent, or both presumptive forms can be observed in single mounts. Conidia one-celled, hyaline, oblong and parallel-sided in plan view (see Olchowecki &

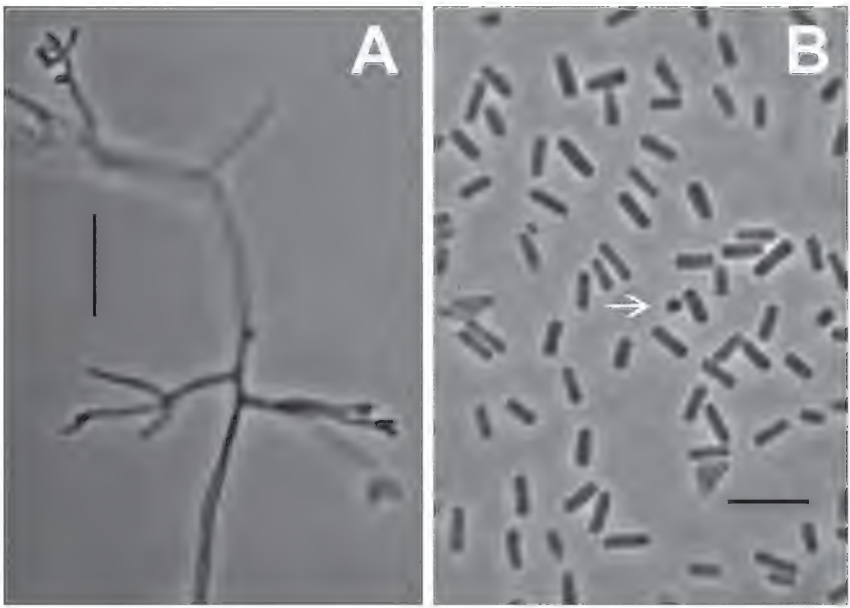



FIG. 4: *Graphilbum tsugae* (wood chip agar cultures). A. Simple conidiophores bearing conidia. B. Conidia in plan view (see Olchowecki & Reid 1974, p.1678 for definition). Scale bars: A = 35 μm; B = 8 μm.

Reid 1974, p. 1678 for definition); generally with slightly rounded ends, but in some cases one end flattened when fully abscised; very uniform in size, cylindrical in cross section (arrow); 3-5(-6) (mean ± s.d. = 4.0 ± 1.05) μm long; frequently produced in slimy masses that occasionally form around the bases of perithecia developing on the wood chips. In such masses the more complicated conidiophores appear.

Mature perithecia black; initials produced abundantly on malt extract supplemented with yeast extract rarely maturing. Abundant mature perithecia developing in two months on plates containing wood chips embedded in the agar. Bases obpyriform, ampulliform, or globose, 75-120 (-168) μm wide (mean ± s.d. = 102 ±16 μm), 75-113 (-140) μm high (mean ± s.d = 94 ± 19 μm). Surface smooth to slightly irregular, often adorned with short dark hair-like hyphae. Neck black, (87-) 138-200 (-280) μm long (mean ± s.d. = 166 ± 49 μm), smooth to occasionally hairy; base 27.5-50 μm wide (mean ± s.d. = 39.1 ± 6.24 μm), tapering to 12.5–25 μm (mean ± s.d. = 18 ± 4.0 μm) just below the point of diverging apical projections; these projections are not ostiolar hyphae, but elongated terminal neck cells, (20-)25-40 μm long (mean ± s.d. = 33.5 ± 7 μm), crooked to jagged cellular extensions that taper to a point, apparently developing by differentiation from normal terminal neck cells; base 2-5 μm

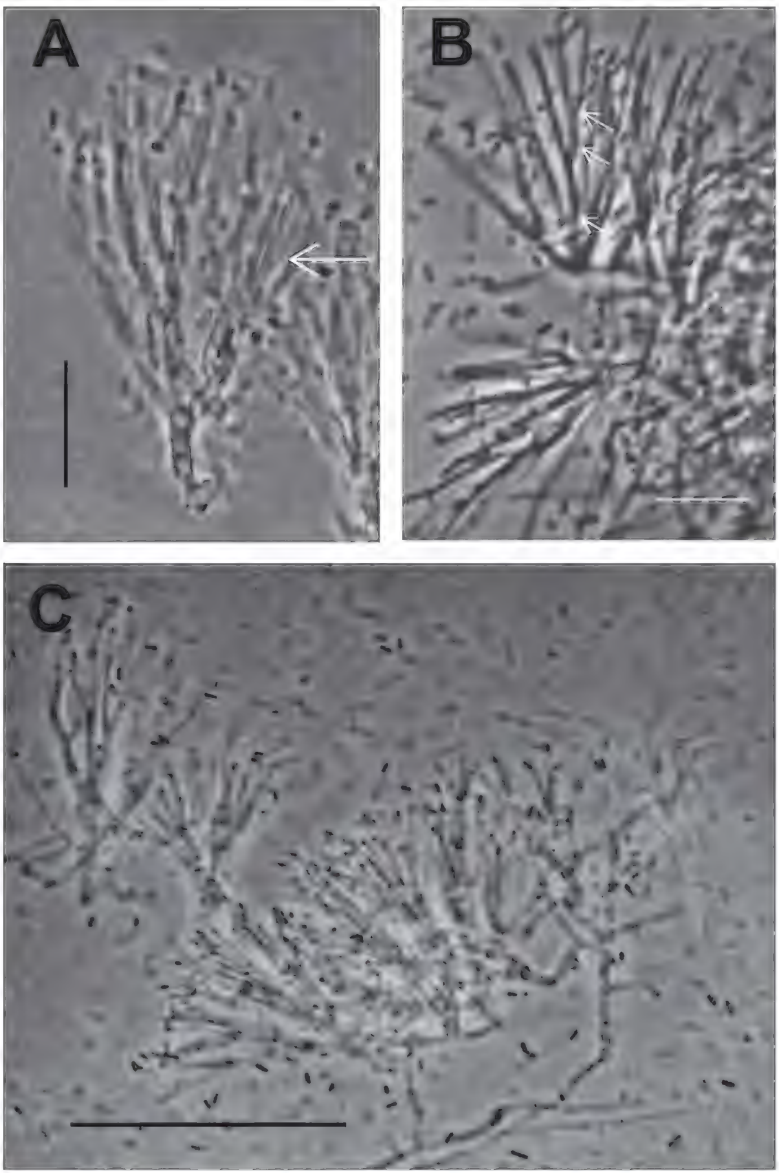
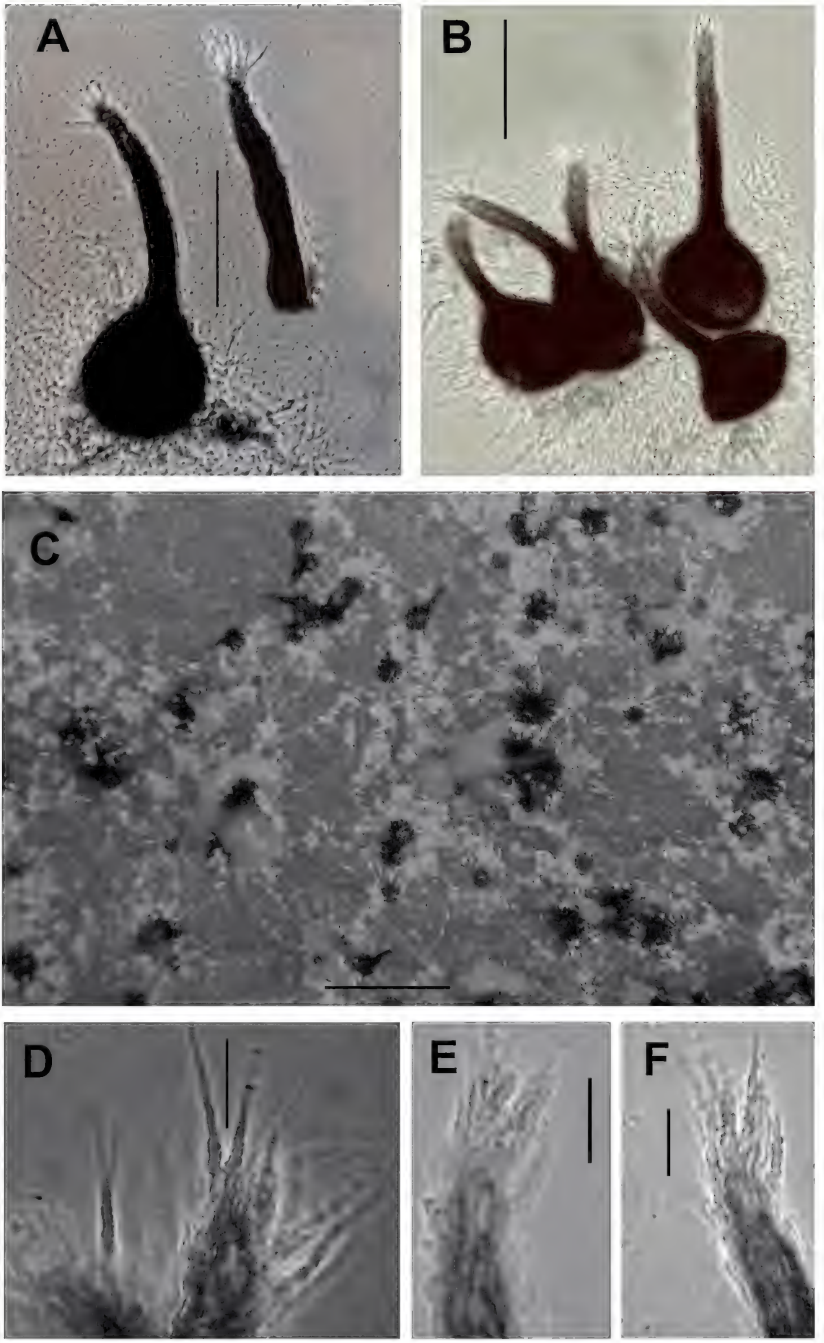



Fig. 5: *Graphilbum tsugae* (wood chip agar cultures). Variously branched conidiophores. A. Single verticillate conidiophore bearing conidia; arising from beneath septum in a parent branch (arrow). B. Portion of a compound aggregation of conidiophores showing successive cymose branches (see Seifert et al. 2011, fig.100D) in a single element (arrows). C. Aggregation of verticillate conidiophores formed in culture on and around the wood chips. Scale bars: A = 12 µm; B = 30 µm; C = 65 µm.


A
B
C
D
E
F

wide (mean ± s.d = 3.5 ± 0.7 µm). Ascospores hyaline, one-celled, oblong to rectangular with slightly rounded ends, rarely slightly constricted in the middle; sheath present but slightly flared and projecting out at the corners in plan view; 3–5 (mean ± s.d. = 3.8 ±. 0.7 × 1.0 µm).

Additional material examined: **CANADA, British Columbia**, Highway 1, Annis Mountain, near Salmon Arm, from a second felled log of *Tsuga heterophylla* at the same location from which the holotype material was obtained, 21 September, 1987. (1) A dried culture grown from isolate WIN(M)1387 (= UAMH 11699] originally isolated aseptically from a slab of stained wood found adjacent to the beetle galleries in the log; (2) A dried culture grown from isolate WIN(M)1384 [= UAMH 11700] that had been isolated from perithecial ooze extruded from a broken perithecium in the beetle galleries in a second small slab of wood taken from this second log. Both samples collected and isolated by J. Reid.

Finally, we correct errors in the citation of:

***Graphium rectangulisporium*** (Ohtaka, Masuya &Yamaoka) Z.W.de Beer & M.J. Wingf. CBS Biodiversity Series 12: 269. 2013 [as "rectangulosporium (R.W. Davidson)"].

≡ *Ophiostoma rectangulisporium* Ohtaka, Masuya & Yamaoka, Can. J. Bot. 84: 290. 2006 [as "*rectangulosporium*"; orthographic correction to comply with McNeill et al. 2012: Art. 60.8].

The miscitation of "R.W. Davidson" as the basionym author appears to have been a transcriptional error.

## Discussion

Kim (2010) and Kim et al. (2011) drew attention to a sterile, white, fast growing isolate (GU393357) obtained from *Orthotomicus erosus* (Wollaston) from *Pinus* spp. growing in California that groups closely with our new species (Fig. 3). However, both its reported growth rate and colour range differ markedly from those of *G. tsugae*. We believe both our morphological data and molecular analysis support our isolates as distinct from all other species formerly assigned to *Ophiostoma*. They are, however, linked by molecular criteria to a small group of other former *Ophiostoma* species whose anamorphs had been considered members of the then anamorphic genus *Graphilbum*. This observation is significant due to recent changes proposed by de Beer et al. (2013a, figs. 2 & 3, pp. 4 & 6) and de Beer & Wingfield (2013, figs. 4b & 5b, pp. 29 & 31). In both these papers *Graphilbum* is used as a holomorph-generic name in trees, and in de Beer & Wingfield (2013), the species group to be included in *Graphilbum* is discussed on page 39.

Fig. 6 (left): *Graphilbum tsugae* (wood chip agar cultures). A–C. Mature perithecia. A. Single mature perithecium and a detached perithecial neck. B. Cluster of five mature perithecia. C. Mature perithecia growing on wood chips in agar medium. Note the droplets in which aggregated conidiophores are often found. D– F. Apical neck projections. Scale bars: A, B = 110 µm; C = 650 µm; D = 15 µm; E = 17 µm; F = 10 µm.

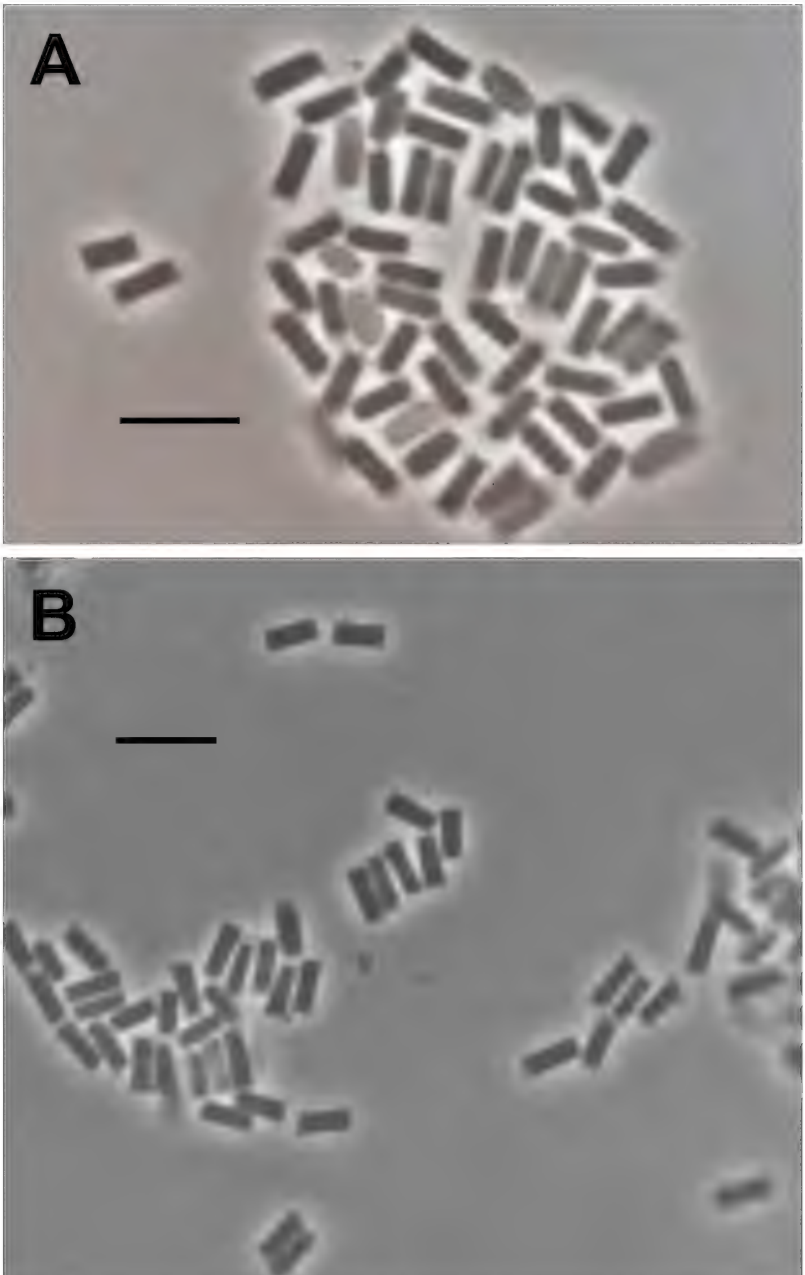



Fig. 7 *Graphilbum tsugae* (wood chip agar cultures). Ascospores. Scale bars: A = 8 µm; B = 7 µm.

De Beer et al. (2013b, p. 268) formally redefined the generic name as:

> *Graphilbum* H.P. Upadhyay & W.B. Kendr., Mycologia 67: 800; 1975 emend. Z.W. de Beer, Seifert & M.J. Wingf. [type species *Gra. sparsum*] = *Ceratocystis* Ellis & Halst. section *Ips* H.P. Upadhyay *pro parte, Monogr. Ceratocystis and Ceratocystiopsis,* p. 70. 1981).

On page 269 discussing *Graphilbum sparsum* H.P. Upadhyay & W.B. Kendr. (1975), de Beer et al. (2013b), also state: ... "*Graphilbum sparsum* is the type species of the genus... re-introduced here to accommodate species previously treated in the *P. fragrans* complex ... ."

Although this resulted in eight species being formally assigned to the genus *Graphilbum* — for only six of which phylogenetic data exists — there is now a ninth: an anamorphic species placed in *Graphilbum* by phylogenetic data (Romón et al. 2014). However, it is clear that de Beer and Wingfield (2013, p. 39) felt strongly that additional isolates studied by them might well deserve similar placement when further supportive data becomes available. Some such potential species are listed with former *Ophiostoma* spp. discussed in their species review under the name of *Graphilbum* (de Beer & Wingfield 2013, p. 39; figs. 4 b, p. 29, 5b, p. 31) and also seen in de Beer et al. (2013a, fig. 3, p. 6). Using phylogenetic data, three other species represented by new combinations in *Hyalorhinocladiella* proposed by Harrington et al. (2010) — *H. ips, H. macrospora, H. tingens* — were shown to represent anamorphs of three different *Ophiostoma* species (de Beer et al. 2013b).

The foregoing changes were made in conformance with the new rule of fungal nomenclature (McNeill et al. 2012, Article 59, Note 2), "... all legitimate fungal names are treated equally... regardless of the life history stage of the type... ." For a history of the origin of this approach see Hawksworth (2011). Following this practice, we describe our holomorphic isolates as representing a new species of the genus *Graphilbum,* originally an anamorphic name as emended above, even though there are some significant morphological inconsistencies among the species now included therein. Our new species introduction will undoubtedly add to these inconsistencies and to the impetus to erect further new genera.

Our ITS sequence analysis, which showed *Graphilbum tsugae* only distantly related to species accommodated in *Ceratocystiopsis*, *Grosmannia,* and *Ophiostoma,* grouped it in a clade previously referred to as the "*P. fragrans* & *O. rectangulosporium* clade" (Jankowiak 2012). Earlier studies based on ITS region analyses also showed that *P. fragrans* and *O. rectangulisporium* form a distinct lineage among the *Ophiostomatales* (Lu et al. 2009, Paciura et al. 2010, Jankowiak & Kolařík 2010, Jankowiak & Bilański 2013ab, Romón et al. 2014), hinting at possible generic status for these taxa. Based on this history, we feel the ITS data support placing our new species, at least for now, in *Graphilbum*.

Because of our ITS data, we critically compared (Table 2) our new species morphologically only to *O. rectangulisporium*, as described and named in Ohtaka et al. (2006). This comparison clearly separates *G. tsugae* from the only other described *Graphilbum* species to which it could possibly have been assigned.

The morphological character that most sets *G. tsugae* apart from all other described *Graphilbum* species are the projections found at the apex of the perithecial neck; we call these ostiolar projections, for they are certainly unlike the more typical ostiolar hyphae that develop in many other species of *Ophiostoma* sensu stricto.

Ostiolar hyphae are commonly found at the perithecial neck apices of many, but not all, *Ophiostoma* species. However, when present, they are generally easily seen during careful examinations, though in some species they can be quite short. They may also be quite long, straight or curved or even spirally curved, parallel-sided or tapered, convergent or divergent, and septate or aseptate and sometimes may have discrete inflated bases. They often simply appear to be extensions of the parallel hyphae comprising the perithecial neck when the neck is so constructed or modified filamentous extensions of the terminal neck cells that are distinctly cellular in structure.

In *G. tsugae*, perithecial necks are apparently composed of relatively thick-walled, primarily oblong to slightly elongate cells. These may also be irregular in outline, but all abut in an interlocking manner and form serially as necks elongate (Fig. 6E).

As the elongation phase of the neck body slows, these cells begin to separate laterally while continuing to elongate apically and tapering to terminate in a sharp point. To us, they resemble "Zeus's thunderbolt." The individual appendages so formed do not appear to be septate (Fig. 6E). We have never previously seen such ostiolar ornamentations.

*Graphilbum,* as emended by de Beer et al. (2013b), will now contain ten formally described species and, based on rDNA data, several undescribed ones. *Graphilbum* species either lack conidial states (*O. rectangulisporium*, Ohtaka et al. 2006) or produce anamorphs ranging between hyalorhinocladiella- to pesotum-like in appearance (de Beer and Wingfield 2013).

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# Molecular analyses reveal a new species in *Melanoderma* from tropical China

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Abstract — A new wood-decaying polypore, *Melanoderma disciforme*, is described from tropical China based on morphological characteristics and rDNA ITS sequences. The new species is characterized by perennial effuse-reflexed basidiocarps, a narrow pileus with a thin black crust on the pileal surface, a dimitic hyphal system with dextrinoid and cyanophilous skeletal hyphae, and the presence of fusiform cystidioles and cylindrical basidiospores. Molecular analyses indicate that the new species and *M. microcarpum* cluster together with full support.

Key words —*Basidiomycota*, *Polyporaceae*, phylogeny, taxonomy

## Introduction

The genus *Melanoderma* B.K. Cui & Y.C. Dai was recently established to accommodate the newly described species *M. microcarpum* B.K. Cui & Y.C. Dai (Cui et al. 2011). The genus is characterized by perennial pileate to effuse-reflexed basidiocarps, a black pileal surface with a thin crust, a dimitic hyphal system with dextrinoid cyanophilous skeletal hyphae, apically encrusted cystidia, and the presence of cystidioles and cylindrical thin-walled basidiospores. Microscopically, *Melanoderma* resembles *Perenniporia* Murrill in having dextrinoid and cyanophilous skeletal hyphae. However, *Melanoderma* is distinguished from *Perenniporia* by its distinctly thin-walled, non-dextrinoid, and acyanophilous basidiospores (Cui et al. 2011).

China is very rich in wood-inhabiting fungi species, and recently extensive studies have been conducted on species diversity, taxonomy, ecological patterns, and phylogeny of wood-inhabiting fungi (Dai 2010, 2011, 2012, Dai et al. 2007, Ma et al. 2011, Zhang et al. 2009, Zhou & Dai 2012). Two polypore specimens collected in 2005 from a tropical forest of Yunnan Province were

subsequently identified and deposited as *Melanoderma microcarpum*. But recent comprehensive morphological and molecular analyses suggest that these specimens represent an undescribed *Melanoderma* species. Here we clarify its taxonomic status and describe it as a new species.

## Materials & methods

### Morphological studies

The specimens studied are deposited in the herbarium of the Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China (IFP). The microscopic procedure follows He & Dai (2012). Sections were studied at magnifications up to ×1000 using a Nikon Eclipse 80i microscope and phase contrast illumination. Measurements were made from sections stained with CB. In presenting basidiospore size variation, the 5% of the measurements excluded from each end of the range are shown in parentheses. The meanings of abbreviations are as follows: CB = cotton blue, CB– = acyanophilous, IKI = Melzer's reagent, IKI– = negative in Melzer's reagent, KOH = 5% potassium hydroxide, L = mean basidiospore length (arithmetic average of all basidiospores), W = mean basidiospore width (arithmetic average of all basidiospores), Q = range of L/W ratios from individual specimens, and n = number of basidiospores measured from given number of specimens. Special color terms follow Petersen (1996).

### Phylogenetic analysis

Total DNA was extracted from specimens using Phire® Plant Direct PCR Kit (Finnzymes, Finland). Primers ITS5 and ITS4 (White et al. 1990) were used to amplify ITS sequences following PCR procedure set forth by Stöger et al. (2006). The DNA was sequenced at Beijing Genomics Institute. The most similar sequences were downloaded from GenBank NCBI (http://www.ncbi.nlm.gov) using the BLAST tool. Sequences were aligned using ClustalX (Thomson et al. 1997) and manually edited to allow maximum alignment and minimize gaps. Maximum parsimony and Bayesian analysis were applied to the ITS dataset. All characters were weighted and gaps were treated as missing data. Maximum parsimony analysis were carried in PAUP* (version 4.0b10; Swofford 2002). Trees were inferred using the heuristic search option with TBR branch swapping and 1,000 random sequence additions. Max-trees were set to 5000 and no-increase, branches of zero length were collapsed, and all parsimonious trees were saved. Nodal support was tested with bootstrap of 1000 replicates using the heuristic search option (TBR and MULTREES options on) (Felsenstein 1985). Descriptive tree statistics tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI) were calculated for all trees generated under different optimality criteria. Bayesian analysis was carried in MrBayes3.1.2 (Ronquist & Huelsenbeck 2003) and models of evolution were identified using MrMODELTEST2.3 (Posada & Crandall 1998, Nylander 2004). Four simultaneous Markov chains were run starting from random trees and keeping one tree every 100th generation until the average standard deviation of split frequencies was below 0.01. The value of burn-in was set to discard 25% of trees when calculating the posterior probabilities. Bayesian posterior probabilities were obtained from the 50% majority rule consensus of the trees kept as support for nodes.

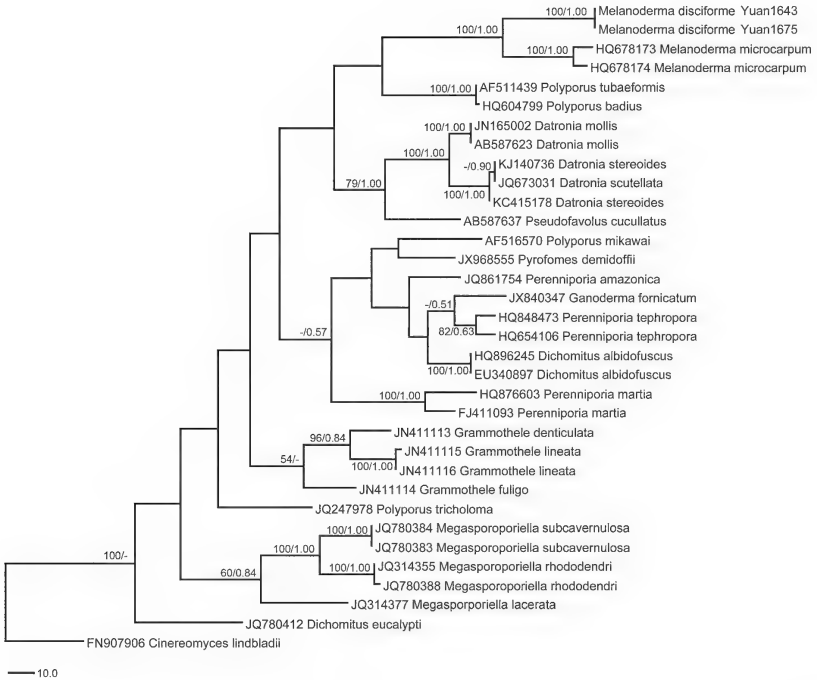


FIG. 1. Strict consensus tree showing the phylogeny of *Melanoderma disciforme* and related species generated by Maximum Likelihood and Bayesian analysis based on ITS sequences. Parsimony bootstrap values >50% and Bayesian posterior probabilities >0.50 are shown on the branches.

## Phylogenetic results

Two ITS sequences were newly generated in this study (GenBank accession numbers KM521268 and KM521269). The ITS dataset contains 34 sequences representing 24 species, among which *Cinereomyces lindbladii* (Berk.) Jülich was selected as outgroup. The alignment comprised 601 characters, of which 297 were constant, 50 were variable but parsimony-uninformative, and 254 were parsimony-informative. Maximum parsimony analysis yielded one parsimonious tree (CI = 0.505, RI = 0.669, RC = 0.338, HI = 0.495). Bayesian analysis ran 5 million generations and resulted in average standard deviation of split frequencies = 0.007737. The 50% majority consensus tree generated by the Bayesian analysis showed a similar topology with the strict consensus MP tree. The strict consensus tree is shown in FIG. 1. Both bootstrap support value (BP) and Bayesian posterior probabilities (BPP) are shown at the nodes. In the phylogenetic tree, two sequences of *M. disciforme* were grouped together with full support (100% BP, 1.00 BPP), and formed a monophyletic lineage with *M. microcarpum* fully supported (100% BP and 1.00 BPP).

## Taxonomy

*Melanoderma disciforme* H.S. Yuan, **sp. nov.** FIG. 2

MycoBank MB 810703

Differs from *Melanoderma microcarpum* by its bigger pores, absence of encrusted cystidia, distinctly smaller cystidioles, and shorter basidiospores.

TYPE: China. Yunnan Prov., Xishuangbanna, Jinghong County, Nabanhe Nat. Res., on fallen angiosperm branch, 15.VIII.2005, Yuan 1675 (**holotype**, IFP; GenBank ITS, KM521269).

ETYMOLOGY: the epithet "*disciforme*" refers to the disk-like basidiocarps.

BASIDIOCARPS: Perennial, effuse-reflexed, growing as round pulvinate patches at first, then fusing laterally, margin narrowly reflexed as a pileus, back attached on substrates, coriaceous when fresh, woody hard upon drying, without odor or taste when fresh; pileus up to 3 mm broad, 5 cm long, and 3 mm thick at base. Pileal surface cream to buff when young, becoming black with a thin crust when aged, concentrically zonate and sulcate, glabrous; margin obtuse, cream to buff, ≤0.5 mm wide. Pore surface white to cream when fresh, buff when dry; pores round to angular, 6–7 per mm, dissepiments thick, entire; sterile margin distinct, ≤0.3 mm wide. Context cream to buff, hard corky, ≤1 mm thick. Tubes cream to buff, corky, distinctly stratified, about 1 mm long for each layer.

HYPHAL STRUCTURE: Hyphal system dimitic; generative hyphae clamped; skeletal hyphae dextrinoid and strongly cyanophilous; tissue unchanged in KOH.

CONTEXT: Generative hyphae scarce, hyaline, thin-walled, rarely branched, 1.5–2.5 μm in diam; skeletal hyphae dominant, hyaline, thick-walled to almost solid, frequently branched, interwoven, 1.5–3 μm in diam.

TUBES: Generative hyphae scarce, hyaline, thin-walled, rarely branched, 2.2–3 μm in diam; skeletal hyphae dominant, hyaline, thick-walled to almost solid, occasionally branched, interwoven, 1–3.5 μm in diam. Cystidia absent; cystidioles fusiform, hyaline, thin-walled, 11–14 × 3–4 μm. Basidia clavate to barrel, with four sterigmata and a basal clamp connection, 10–13 × 5–6 μm; basidioles similar in shape to basidia, but slightly smaller. Polygonal crystals frequently present in trama.

BASIDIOSPORES: Cylindrical, hyaline, thin-walled, smooth, IKI–, CB–, (4.8–)4.9–5.3(–5.5) × (1.9–)2–2.3(–2.5) μm, L = 5.05 μm, W = 2.17 μm, Q = 2.32–2.34 (n = 34/2).

TYPE OF ROT: Causes a white rot in angiosperms.

ADDITIONAL SPECIMENS EXAMINED: *Melanoderma disciforme*: **CHINA. YUNNAN PROV.**, Xishuangbanna, Jinghong County, Nabanhe Nat. Res., fallen angiosperm branch, 15.VIII.2005, Yuan 1643 (IFP; GenBank ITS: KM521268).

*Melanoderma microcarpum*: **CHINA. HUNAN PROV.**, Yizhang County, Mangshan Forest Park, on fallen angiosperm trunk, 25.VI.2007, Dai 8116 (BJFC, holotype).

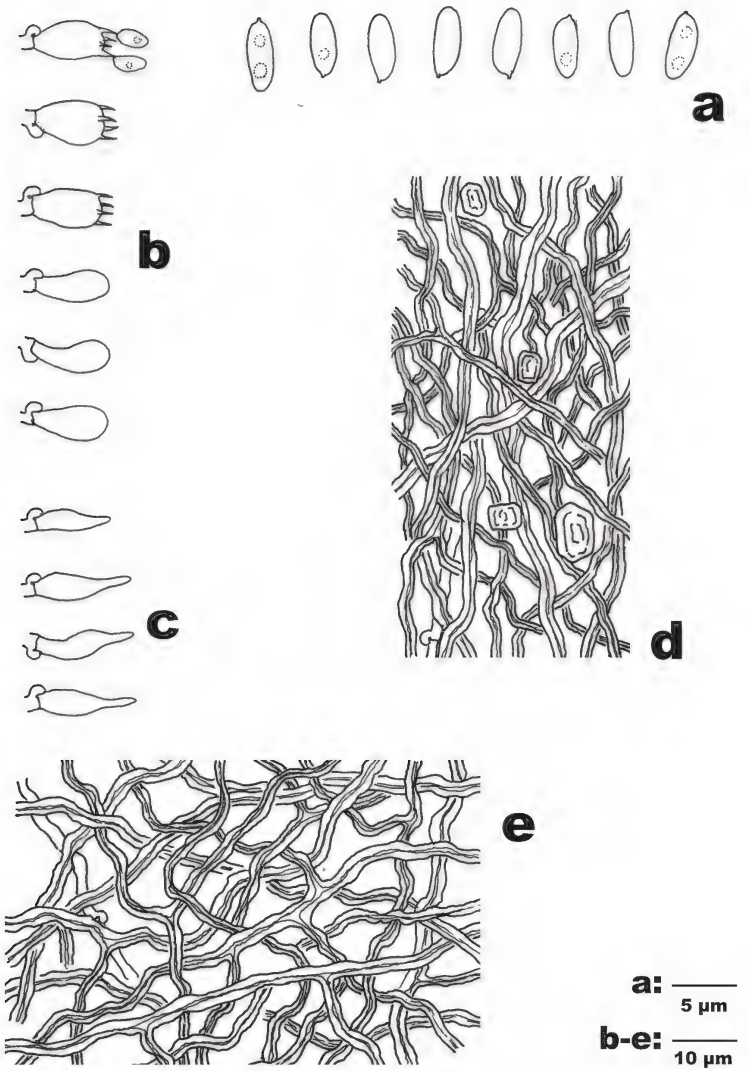


FIG. 2. *Melanoderma disciforme* microscopic structures (Yuan 1675, holotype). a. Basidiospores; b. Basidia and basidioles; c. Cystidioles; d. Hyphae from trama; e. Hyphae from subiculum.

## Discussion

*Melanoderma disciforme* represents the second species in the genus. It is characterized by perennial effuse-reflexed basidiocarps, narrow pileus with a thin black crust on the pileal surface, fusiform cystidioles, and cylindrical

basidiospores. The molecular phylogeny and morphological evidences support it as a new species.

*Melanoderma disciforme* shares most of the morphological features with *M. microcarpum*, the type species of the genus, which differs by smaller pores (7–9 per mm), apically encrusted cystidia, distinctly larger cystidioles, and longer basidiospores.

Species in *Perenniporia*, *Megasporoporiella* B.K. Cui et al., *Datronia* Donk, and *Dichomitus* D.A. Reid are morphologically similar to *M. disciforme* by having a dimitic hyphal system with cyanophilous skeletal hyphae. However, *Perenniporia* species have thick-walled basidiospores, *Megasporoporiella* species lack a crust on the surface of the pileus, and *Datronia* and *Dichomitus* species have non-dextrinoid skeletal hyphae (Núñez & Ryvarden 2001, Li & Cui 2013). Additionally, phylogenetic analyses based on ITS sequences indicate that species sampled from these genera are not genetically close to *M. disciforme*.

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# *Graphis hongkongensis* sp. nov. and other *Graphis* spp. new to Hong Kong

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Abstract — Eleven *Graphis* species are newly recorded from Hong Kong. *Graphis hongkongensis* is new to science, *G. centrifuga* and *G. hyphosa* are new to China, and *G. assimilis, G. descissa, G. duplicata, G. immersella, G. immersicans, G. japonica, G. parallela,* and *G. plagiocarpa* are new to Hong Kong. *Graphis hongkongensis* possesses *lineola*-morph lirellae, a completely carbonized exciple, small to medium-sized ascospores, and the presence of stictic acid. A brief description of each species is given.

Key words — *Graphidaceae*, lichenized fungi, new species

## Introduction

*Graphidaceae,* with over 2300 species belonging to more than 50 genera, is considered the largest crustose lichen community (Lücking et al. 2009; Rivas Plata et al. 2010, 2012; Rivas Plata & Lücking 2013). *Graphis,* its type genus, is characterized by lirelliform ascomata; a carbonized proper exciple; a hymenium inspersed with granules or not; hyaline, transversely septate to muriform, amyloid ascospores reacting blue or blue-violet in iodine; and the presence or absence of lichen compounds. There are more than 70 *Graphis* species in China (Jia & Wei 2008, 2009, 2011; Jia 2011, Jia et al. 2012), of which 18 taxa have been reported previously in Hong Kong (Thrower 1988, Wei 1991, Aptroot & Seaward 1999, Aptroot & Sipman 2001, Seaward & Aptroot 2005).

A revision of *Graphis* from Hong Kong conducted under the frame of the Flora Lichenum Sinicorum resulted in the discovery of 11 new records for Hong Kong, including a new species, *Graphis hongkongensis*, and two new records for China, *G. centrifuga* and *G. hyphosa.*

## Materials & methods

Hong Kong, special Administrative Region of the People's Republic of China, is located at the southern coast of China with subtropical climate. Material was collected mainly from Hong Kong in 2011 and is preserved in the Herbarium Mycologicum Academiae Sinicae-Lichenes (HMAS-L). A Motic SMZ-168 dissecting microscope (Scientific Instrument Company, Inc., Campbell, USA) and Zeiss Axioskop 2 plus compound microscopes (Zeiss Scope, Oberkochen, Germany) in part connected to Nikon D50 digital microscope cameras (Nikon, Tokyo, Japan) were used for the morphological and anatomical examinations. Lugol's solution, spot tests, and TLC in solvent system C (toluene : acetic acid = 200 : 30) were used for chemical study (Culberson & Kristensson 1970, Culberson 1972, White & James 1985).

## Taxonomy

***Graphis assimilis*** Nyl., Bull. Soc. Linn. Normandie, sér. 2, 2: 109. 1868.

Thallus, off-white. Ascomata, sinuous, immersed to erumpent, simple to branched, sometimes clustered (*lineola*-morph); labia, entire proper exciple, completely carbonized; hymenium, not inspersed; ascospores 8/ascus, transversely 8–10-locular, hyaline, 35–50 × 7.5–8.75 µm, I+ blue.

Chemistry: Norstictic acid detected in TLC.

Distribution & ecology: Eastern palaeotropical (Lücking et al. 2009); new to Hong Kong. This corticolous species was previously known from China (Jia & Wei 2011) and India (Adawadkar & Makhija 2006, 2007).

Specimen examined: **Hong Kong. Lautau Island**, the road from Lautau Peak to Nam Shan, 22°14′N 113°56′E, alt. 384 m, on bark of tree, 15 Dec. 2011,Wei Guo & Jinxiu Tian HK367.

Remarks: This species is anatomically and chemically similar to *Graphis intricata* Fée, which differs in its *deserpens*-or *centrifuga*-morph lirellae and smaller ascospores (15–30 µm long).

***Graphis centrifuga*** Räsänen, Suom. Elain-ja Kasvit. Seuran Van. Tiedon. Pöytäkirjat 3: 186. 1949.

Thallus, yellowish grey. Lirellae, immersed to sessile, in satellite clusters (*centrifuga*-morph); proper exciple, completely carbonized; hymenium, 100–120 µm high, inspersed; ascospores, 8/ascus, transversely 6–8-locular, hyaline, 20–25 × 5–10 µm, I–.

Chemistry: Norstictic acid detected in TLC.

Distribution & ecology: Eastern palaeotropical (Lücking et al. 2009); new to China. *Graphis centrifuga* is a corticolous species known also from Australia (Staiger 2002).

Specimen examined: **HONG KONG, New Territories**, Ma On Shan, Mui Tsz Lam, 22°23′N 114°14′E, alt. 187 m, 14 Dec. 2011, Wei Guo HK358.

Remarks: *Graphis centrifuga* most closely resembles *G. cervinonigra* Zahlbr., which differs in its short lirellae (*coarctata*-morph).

***Graphis descissa*** Müll. Arg., Bull. Herb. Boissier 3: 318. 1895.

Thallus, off-white. Labia entire; lirellae immersed (*subserpentina*-morph); proper exciple completely carbonized; hymenium 100–120 µm high, not inspersed; ascospores 8/ascus, transversely 8–10-locular, (20–)28–37 × 6.25–8 µm, I+ blue.

Chemistry: Stictic acid.

Distribution & ecology: Neotropical and eastern palaeotropical (Lücking et al. 2009); new to Hong Kong. The species is an inconspicuous, corticolous species that also occurs in Australia (Archer 2006).

Specimen examined: **HONG KONG, New Territories**, Ma On Shan, Mui Tsz Lam, 22°23′N 114°14′E, alt. 187 m, 14 Dec. 2011, Wei Guo HK356–1.

Remarks: *Graphis descissa* resembles *G. flavovirens* Makhija & Adaw. in its thallus containing stictic acid, but the lirellae in *G. flavovirens* are very long and radially branched (*centrifuga*-morph).

***Graphis duplicata*** Ach., Syn. Meth. Lich.: 81. 1814.

Thallus, whitish grey to grey. Labia striate (*striatula*-morph); proper exciple laterally carbonized; ascospores 8/ascus, transversely 8–9-locular, hyaline, 32.5–42.5 × 5–7.5 µm, I+ blue.

Chemistry: No lichen compounds detected in TLC.

Distribution & ecology: Pantropical (Lücking et al. 2009); new to Hong Kong. *Graphis duplicata* is a widely distributed species, found on tree bark in China (Jia & Wei 2011), India (Adawadkar & Makhija 2007), and South America, Philippines, Indonesia, and Australia (Staiger 2002, Archer 2006).

Specimen examined: **HONG KONG, New Territories**, Ma On Shan, Mui Tsz Lam, 22°23′N 114°14′E, alt. 70 m, 14 Dec. 2011, Wei Guo HK349–3.

Remarks: *Graphis duplicata* can be distinguished from *G. tenella* Ach. in having *striatula*-morph lirellae and from *G. striatula* (Ach.) Spreng. in having smaller ascospores.

***Graphis hongkongensis*** Wei Guo & J.S. Hur, **sp. nov.** Plate 1

Fungal Name FN570089

Differs from *Graphis gloriosensis* by its *lineola*-morph lirellae and its smaller ascospores with less trans-septation.

Type– China, Hong Kong, Lautau Island, the road from Lautau Peak to Nam Shan, on bark, 22°14′N 113°56′E, alt. 384 m, 15 Dec. 2011, W. Guo & J.X. Tian HK365 (**Holotype**, HMAS-L 128226).

Etymology– referring to the type locality, Hong Kong.

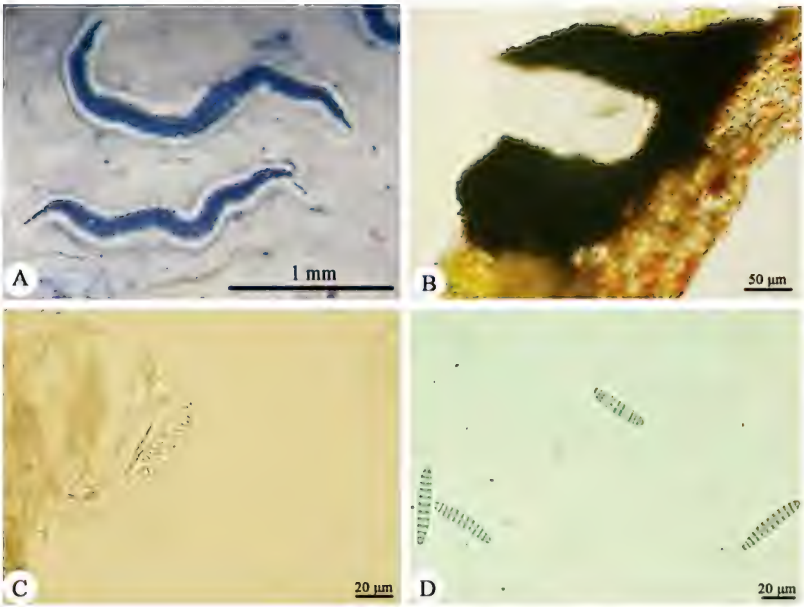


Plate 1. *Graphis hongkongensis* (holotype, HMAS-L 128226). A, habit; B, cross-section of an apothecium; C, ascus with ascospores; D, ascospores.

Thallus pale grayish white to pale white, smooth. Ascomata lirelliform, submersed to erumpent, simple to sparsely branched, 1–4 mm long, 0.2–0.3 mm wide. Disc concealed (narrow to slightly open), blackish brown to black, without pruina. Thalline margin lateral, well developed (*lineola*-morph lirellae). Proper exciple completely carbonized. Hymenium colourless, inspersed, 90–135 µm high, I–. Paraphyses unbranched, dense, thin, 1.25–2.5 µm wide, filiform, warty in tips.

Asci 6–8-spored, 82.5–100 × 17.5–25 µm. Ascospores fusiform, transversely 8–12-locular, 25–50 × 7.5–10 µm, I+ violet-blue.

Chemistry: Stictic acid detected in TLC.

Remarks: *Graphis hongkongensis* closely resembles *G. gloriosensis* A.W. Archer & Elix in having entire labia, a lateral thalline margin, a completely carbonized excipulum, an inspersed hymenium, transversely septate ascospores, and a thallus containing stictic acid. However, *G. gloriosensis* is distinguished by *marginata*-morph lirellae, comparatively larger ascospores (50–90 × 9–16 µm) with more trans-septation, and being so far known only from Australia (Lücking et al. 2009).

*Graphis kelungana* Zahlbr., which resembles *G. hongkongensis* in having entire labia, an inspersed hymenium, transversely septate and similarly sized ascospores, a thallus containing stictic acid, and a similar geographical

distribution, is clearly separated by its lateral carbonization and *subserpentina*-morph lirellae. *Graphis lineola* Ach., which has similar lirellae morphology and shares most of the anatomical characteristics with *G. hongkongensis*, differs by its laterally carbonized excipulum and a thallus lacking lichen compounds.

***Graphis hyphosa*** Staiger, Bibl. Lichenol. 85: 235. 2002.

Thallus, light yellow to yellowish grey. Ascomata immersed in pseudostromata, stellately branched (*hyphosa*-morph); labia entire; proper exciple completely carbonized; hymenium clear; ascospores 4–8/ascus, transversely 6–9-locular, hyaline, 20–37.5 × 7.5-10 µm, I+ blue.

Chemistry: No lichen compounds detected in TLC.

Distribution & ecology: Neotropical (Lücking et al. 2009). New to China. *Graphis hyphosa* occurs on tree bark in Costa Rica and Brazil (Staiger 2002).

Specimen examined: **HONG KONG, Lautau Island**, the road from Lautau Peak to Nam Shan, 22°14′N 113°56′E, alt. 384 m, 15 Dec. 2011, Wei Guo & Jinxiu Tian HK370.

Remarks: *Graphis intricata*, which also has entire labia, a completely carbonized excipulum, a clear hymenium, and transversely septate ascospores, can easily be distinguished from *G. hyphosa* by its *deserpens*- or *centrifuga*-morph, smaller ascospores, and thallus containing norstictic acid.

***Graphis immersella*** Müll. Arg., Bull. Herb. Boissier 3: 319. 1895.

Thallus off-white. Ascomata lirellae, entire labia, *lineola*-morph; proper exciple, laterally carbonized; hymenium, not inspersed; ascospores 8/ascus, transversely 6–11-locular, hyaline, 20–47.5 × 7.5–12.5 µm, I+ blue.

Chemistry: Stictic acid detected in TLC.

Distribution & ecology: Palaeotropical (Lücking et al. 2009); new to Hong Kong. The species is a corticolous species known from China (Jia & Wei 2011, Zahlbruckner 1930); the Solomon Islands, Christmas Island, and Vanuatu (Archer 2006); Australia (Archer 1999); and India (Adawadkar & Makhija 2007).

Specimen examined: **HONG KONG, New Territories**, Tai Mo Shan, 22°24′N 114°54′E, alt. 906 m, 11 Dec. 2011, Meng Liu HK218.

Remarks: *Graphis immersella* resembles *G. leptogramma* Nyl. in ascomatal anatomy and a thallus producing stictic acid but differs in its slightly smaller ascospores.

***Graphis immersicans*** A.W. Archer, Aust. Syst. Bot. 14: 262. 2001.

Thallus, whitish grey. Ascomata lirellae, erumpent (*lineola*-or *deserpens*-morph); proper exciple, completely carbonized; hymenium 70–90 µm high, not inspersed; ascospores, 4–6/ascus, transversely 6–12-locular, hyaline, 25–45 × 7.5–10 µm, I+ blue.

Chemistry: No lichen compounds detected in TLC.

Distribution & ecology: Pantropical (Lücking et al. 2009); new to Hong Kong. This corticolous species was previously reported from China (Jia & Wei 2011), Australia (Archer 2006), and Philippines (Lücking et al. 2008)

Specimen examined: **HONG KONG, New Territories**, Ma On Shan, Mui Tsz Lam, 22°23′N 114°14′E, alt. 187 m, 14 Dec. 2011, Wei Guo HK359.

Remarks: *Graphis immersicans* is close to *G. immersella* in lirellate morphology, but *G. immersella* can be distinguished by its laterally carbonized excipulum and thallus producing stictic acid.

***Graphis japonica*** (Müll. Arg.) A.W. Archer & Lücking, Lichenologist 41: 437. 2009.

Thallus, green to greyish green. Ascomata lirellae, *subserpentina*-morph; proper exciple apically to laterally carbonized; hymenium, 140–160 µm high, not inspersed; ascospores, 4/ascus, muriform, 10–13/2–4-locular, hyaline, 30–67.5 × 12.5–20 µm, I+ blue.

Chemistry: Stictic acid detected.

Distribution & ecology: Eastern palaeotropical (Lücking et al. 2009); new to Hong Kong. *Graphis japonica* predominantly grows on trees and has been previously reported from China (Lamb 1963, Wang-Yang & Lai 1973, Jia & Wei 2011) and Japan (Nakanishi 1966, Nakanishi et al. 2003).

Specimens examined: **HONG KONG, New Territories**, Tai Po Kau Country Park, Blue Road, 22°25′N 114°10′E, alt. 136 m, 10 Dec. 2011, Jinxiu Tian HK047, HK052; the road from Nam Chung to Bride Pool, 22°38′N 114°12′E, alt. 41 m, 9 Dec. 2011, Xinli Wei & Meng Liu HK009.

Remarks: This species is most similar to *Graphis streblocarpa* (Bél.) Nyl. in all morpho-anatomical and chemical characteristics, but *G. streblocarpa* has larger ascospores and 1–2-spored asci.

***Graphis parallela*** Müll. Arg., Nuovo Giorn. Bot. Ital. 29: 200. 1892.

Thallus, whitish grey to ivory-white. Ascomata lirellae *opegrapha*-morph; labia entire; proper exciple completely carbonized; hymenium, not inspersed; ascospores 2–4/ascus, transversely 16–23-locular, hyaline, (35–)65–112.5 × (7.5–)10–15 µm, I+ blue.

Chemistry: No lichen compounds detected.

Distribution & ecology: Eastern palaeotropical (Lücking et al. 2009); new to Hong Kong. This corticolous species was previously reported from China (Jia & Wei 2011) and Japan (Nakanishi 1966).

Specimen examined: **HONG KONG, New Territories**, Ma On Shan, Mui Tsz Lam, 22°23′N 114°14′E, alt. 184 m, 14 Dec. 2011, Meng Liu HK269.

Remarks: *Graphis parallela* is nearest to *G. bifera* Zahlbr., which differs by its considerably shorter, unbranched sessile, *opegrapha*-morph lirellae.

***Graphis plagiocarpa*** Fée, Essai Crypt. Écorc.: 38. 1825.

Thallus off-white to greyish white. Ascomata lirellae, *dussii*-morph; labia entire; proper exciple completely carbonized; hymenium, not inspersed; ascospores, 2/ascus, muriform, hyaline, (20–)25–28/1–5-locular, 90–150 × (25–) 40–50 µm, I+ blue.

Chemistry: No lichen compounds detected.

Distribution & ecology: Pantropical (Lücking et al. 2009); new to Hong Kong. *G. plagiocarpa* is a corticolous species previously recorded from China (Jia & Wei 2011), Japan (Nakanishi 1966; Yoshimura 1974), Europe (Staiger 2002) and Australia (Archer 2005).

Specimens examined: **HONG KONG**, **New Territories**, Tai Po Kau Country Park, Blue Road, 22°25′N 114°10′E, alt. 157 m, 10 Dec. 2011, Meng Liu HK041–2; Kadoori Garden, Kwun Yam Shan, 22°25′N 114°07′E, alt. 550 m, 12 Dec. 2012, Meng Liu HK242, HK237.

Remarks: *Graphis plagiocarpa* is very similar to *G. lumbschii* (A.W. Archer) A.W. Archer in lirellate morphology but differs in lacking lichen compounds. *Graphis cleistoblephara* Nyl. and *G. sorsogona* Vain. also have short unbranched lirellae (*dussii*-morph), but *G. cleistoblephara* produces norstictic acid, and *G. sorsogona* has a laterally carbonized exciple.

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# Two new conidial fungi from Chapada Diamantina, Brazil

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Abstract —*Phaeoschizotrichum ramosum* gen. & sp. nov. and *Pyriculariopsis bicolorata* sp. nov., two new asexual fungi collected on leaves of *Calophyllum brasiliense* in the Brazilian semiarid Caatinga region, are described and illustrated. *Phaeoschizotrichum ramosum* is characterized by distinctly branched conidiophores, discrete, terminal, sympodially extended conidiogenous cells, and subulate to narrowly obclavate, 1–4-septate, pale brown conidia. *Pyriculariopsis bicolorata* is distinguished by conidia that are obclavate to subulate, 1-septate, bicolored, and smooth.

Key words — microfungi, taxonomy, leaf litter

## Introduction

During an investigation of conidial fungi associated with decaying leaves of *Calophyllum brasiliense* Cambess. (*Clusiaceae*) in a riparian forest of Chapada Diamantina (Piatã, Bahia) in the semiarid Caatinga region of Brazil, two interesting fungi were collected. One was remarkably different from all previously described hyphomycete genera (Seifert et al. 2011) while the other differed from all *Pyriculariopsis* species (Iturriaga et al. 2008, Soares et al. 2011). The two fungi are therefore described here as new.

## Materials & methods

During studies in periods September 2013 to July 2014 leaves of *C., brasiliense* were collected in Piatã, Bahia. The material was taken to the laboratory using the methodology by Castañeda-Ruiz (2005). Sample leaves of *C. brasiliense* were placed in plastic bags. In

the laboratory the samples were washed, placed in Petri dish moist chambers, and stored in a polystyrene box with sterile water plus glycerol for 30 days. Slide mounts were prepared in PVL (polyvinyl alcohol, lactic acid, and phenol) and measurements were made at a magnification of ×1000. Microphotographs were obtained with an Olympus microscope (model BX51) equipped with bright field and Nomarski interference optics. The type specimens are deposited in the Herbarium of Universidade Estadual de Feira de Santana, Brazil (HUEFS).

## Taxonomy

***Phaeoschizotrichum*** C.R. Silva, Gusmão & R.F. Castañeda, **gen. nov.**

MycoBank MB810712

Differs from *Schizotrichum* by its mostly branched conidiophores, its percurrent and sympodially extended small denticulate and slightly melanized conidiogenous cells, and its pale brown to brown conidia.

Type Species: *Phaeoschizotrichum ramosum* C.R. Silva et al.

Etymology: Greek, *Phaeo-*, meaning dark, referring to the pale brown conidial pigmentation; Latin, *-schizotrichum* referring to the hyphomycete genus *Schizotrichum.*

Colonies hairy, effuse, brown. Mycelium superficial. Conidiophores distinct, single, mostly branched above, septate, brown to dark brown. Conidiogenous cells polyblastic, denticulate, integrated or discrete, enteroblastic percurrent elongated and sympodial extensions, terminal. Conidial secession schizolytic. Conidia solitary, subulate, narrow obclavate to subcylindrical, euseptate, pale brown to brown, smooth or verruculose.

Note: *Phaeoschizotrichum* superficially resembles *Schizotrichum* McAlpine (Ellis 1971, Seifert et al. 2011), but *Schizotrichum* has immersed mycelium and forms erumpent dark brown textura angularis stromata; setae are sometimes present and unbranched, dark brown, and thick-walled while its conidiophores are caespitose, unbranched, and bear sympodial elongated conidiogenous cells and subulate or filiform, smooth, hyaline conidia. *Phaeoschizotrichum* also superficially resembles other cercosporoid fungi with pale or dark pigmented conidia that are known to cause foliar diseases, such as *Passalora* Fr. and *Pseudocercospora* Speg.

***Phaeoschizotrichum ramosum*** C.R. Silva, Gusmão & R.F. Castañeda, **sp. nov.**

MycoBank MB810713 Figs 1, 2

Differs from *Schizotrichum lobeliae* by its superficial mycelium composing an anastomosed network of hyphae with a textura epidermoidea appearance, its mostly branched multi-septate ventricose conidiophores, and its pale brown conidia.

Type: Brazil, Bahia, Piatã, Serra da Tromba, 13°07'S 41°50'W, on dead leaf of *Calophyllum brasiliense*, 19 XI. 2013, coll. C.R. Silva (**Holotype**: HUEFS 210423).

Etymology: Latin, *ramosum,* referring to the branched conidiophores.

Fig. 1. *Phaeoschizotrichum ramosum* (ex HUEFS 210423). A–D. Conidia. E–H. Conidiogenous cells. I–K. Conidiophores and conidiogenous cells.

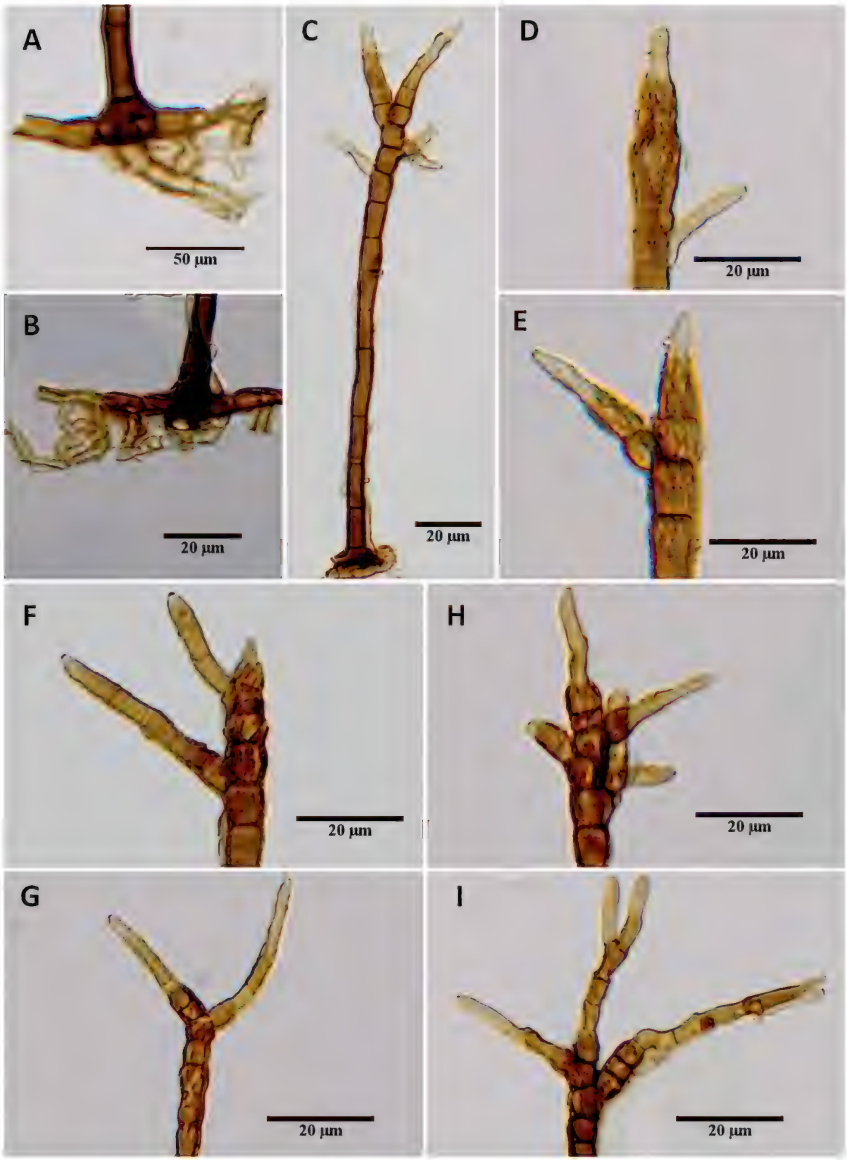


Fig. 2. *Phaeoschizotrichum ramosum* (ex HUEFS 210423). A–B. Hyphae and conidiophore basal cells. C. Conidiophore and conidiogenous cells. D–I. Branches with fissured outer cell walls and conidiogenous cells.

Colonies on the natural substratum, effuse, hairy, amphigenous, brown. Mycelium superficial, composed of septate, pale brown, 2–4 µm wide, smooth, branched hyphae, forming an anastomosed network of textura epidermoidea appearance. Conidiophores distinct, single, rarely unbranched, mostly branched above, erect, cylindrical, smooth near the base, ventricose, closely septate, with fissured outer cell walls near the apex and branches, with up to 10 enteroblastic percurrent extensions in the main axis and branches, brown below, subhyaline to pale brown above, 100–200 × 5–10 µm. Conidiogenous cells polyblastic, cylindrical-subulate, slightly denticulate, weakly melanized at the conidiogenous loci, subhyaline to pale brown, sympodially elongated after enteroblastic percurrent extensions, smooth sometimes cracked, furrowed or leprous near the percurrent elongation, 15–50 × 4–5 µm. Conidia solitary, subulate, narrowly obclavate, truncate, slightly obscure at the base, rounded or obtuse at the apex, 1–4-septate, mostly 3-septate, pale brown, 25–68 × 2.5–4 µm, smooth, rarely verruculose, dry.

***Pyriculariopsis bicolorata*** C.R. Silva, Gusmão & R.F. Castañeda, **sp. nov.** Fig. 3

MycoBank MB810714

Differs from *Pyriculariopsis* spp. by smaller, 1-septate, bicolored conidia.

Type: Brazil, Bahia, Piatã, Serra da Tromba, 13°07'S 41°50'W, on dead leaf of *Calophyllum brasiliense*, 2 X. 2013, coll. C.R. Silva (**Holotype**: HUEFS 210424).

Etymology: Latin, *bicolorata*, referring to the two-colored conidia.

Colonies on the natural substratum, effuse, hairy, hypophyllous, brown. Mycelium superficial and immersed, composed of septate, branched, brown, 1–2 µm wide, smooth hyphae. Conidiophores distinct, single, develop as lateral branch of hyphae, unbranched, cylindrical, straight to slightly flexuous, 4–7-septate, brown dark at the base becoming paler to the apex, with 2–5 percurrent extensions, 75–175 × 2.5–4 µm, smooth. Conidial secession schizolytic. Conidiogenous cells polyblastic, integrated, mostly terminal, sometimes intercalary, sympodially elongated, slightly denticulate, pale brown, 15–47.5 × 2.5–4 µm, slightly cicatrized at the loci. Conidia obclavate, truncate at the base, obtuse and rounded apex, slightly constricted at the septa, 1-septate, bicolored, brown basal cell, subhyaline apical cell, single, dry, 12–18 × 2.5–4 µm.

Note: A key to eight *Pyriculariopsis* species with conidial illustrations was provided by Iturriaga et al. (2008); subsequently Soares et al. (2011) named *P. calatheae*, which is characterized by cylindrical-fusiform to obclavate, 18–36 × 5–7 µm, 1–2-septate, often with a rostrate apical cell, 3–12 × 2–4 µm, pale brown to subhyaline. None of the nine previously described species of *Pyriculariopsis* is close to or resembles *P. bicolorata*.

Fig. 3. *Pyriculariopsis bicolorata* (ex HUEFS 210424). A–E. Conidia. F. Conidium and conidiogenous cells. G–H. Conidiogenous cells. I. Conidiophore with external hyphae.

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# *Anaexserticlava caatingae*, a new conidial fungus from the semi-arid Caatinga biome of Brazil

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Abstract—An interesting fungus collected during investigations of microfungi on dead plant material in a semi-arid region of northeast Brazil is herein described and illustrated. *Anaexserticlava caatingae* gen. & sp. nov. is distinguished by differentiated dark brown conidiophores, holoblastic percurrent elongated conidiogenous cells that produce several sessile subcylindrical hyaline separating cells, and clavate to ovoid 5–6-distoseptate brown conidia.

Key words— asexual ascomycete, systematic, leaf litter, tropics

The semi-arid region of Brazil is located almost exclusively in the northeast region of the country occupying an area of approximately 900,000 km$^2$ (Giulietti et al. 2006). The Caatinga biome is the predominant vegetation and several new microfungi have recently been described in this region (Almeida et al. 2013, 2014; Barbosa et al. 2013; Cruz et al. 2012; Fiuza et al. 2014; Leão-Ferreira et al. 2013; Silva & Gusmão 2013; Silva et al. 2014). During a mycological survey of conidial fungi from the semi-arid region in Bahia and Piauí States, an interesting fungus was collected and showed remarkable differences from all previously described hyphomycete genera (Seifert et al. 2011). The specimen is therefore described as a new genus.

The samples of dead plant material were placed in paper bags, taken to the laboratory, and prepared according to Castañeda-Ruiz (2005). Mounts were prepared in PVL (polyvinyl alcohol, lactic acid, and phenol) and measurements were made at 1000× magnification. Microphotographs were obtained with an Olympus BX51 microscope equipped with bright field and Nomarski interference optics. The type specimen is deposited in the Herbarium of Universidade Estadual de Feira de Santana (HUEFS) and an additional specimen collected from another field expedition in the Herbarium of Universidade do Estado da Bahia (HUNEB/SB), Brazil.

***Anaexserticlava*** T.S. Santa Izabel, R.F. Castañeda & Gusmão, **gen. nov.**

MycoBank MB810632

Differs from *Exserticlava* by sessile, subcylindrical, hyaline separating cells and rhexolytic conidial secession.

Type species: *Anaexserticlava caatingae* T.S. Santa Izabel et al.

Etymology: Latin, *Anaexserticlava*, named after its morphological similarities to the hyphomycete genus *Exserticlava*.

Asexual fungi. Conidiophores distinct, single, unbranched, erect, straight, septate, smooth, dark brown. Conidiogenous cell holoblastic, integrated, terminal, with several enteroblastic percurrent extensions; conidial secession rhexolytic. Separating cells sessile, cylindrical to subcylindrical, hyaline. Conidia solitary, clavate to ovoid, distoseptate, pedicellate, smooth, first pale brown, later brown.

***Anaexserticlava caatingae*** T.S. Santa Izabel, R.F. Castañeda & Gusmão, **sp. nov.**

MycoBank MB810633 Fig. 1

Differs from *Exserticlava* spp. by having sessile, subcylindrical to doliiform, hyaline separating cells and pedicellate conidia.

Type: Brazil, Piauí, Caracol, Serra das Confusões, 9°13′S, 43°29′W, on decaying leaves of an unidentified plant, 4.V.2011, coll. D.A.C. Almeida (**Holotype**: HUEFS173319).

Etymology: Latin, *caatingae,* referring to the Caatinga biome.

Colonies on the natural substrate effuse, hairy, brown. Mycelium mostly immersed, composed of branched, septate, smooth, pale brown hyphae, 1–2 µm diam. Conidiophores distinct, single, unbranched, erect, straight or slightly flexuous, septate, smooth, dark brown, pale brown toward the apex, 100–200 × 7.5–10 µm. Conidiogenous cells holoblastic, integrated, terminal, with several enteroblastic percurrent extensions, smooth, pale brown. Separating cells sessile, doliiform to subcylindrical, hyaline or subhyaline. Conidial secession rhexolytic. Conidia solitary, clavate to ovoid, rounded at the ends, pedicellate, 5–6-distoseptate, smooth, pale brown at first, brown after maturation, 20–27.5 × 7.5–12.5 µm; pedicels 3–4.5 × 1.5–3 µm.

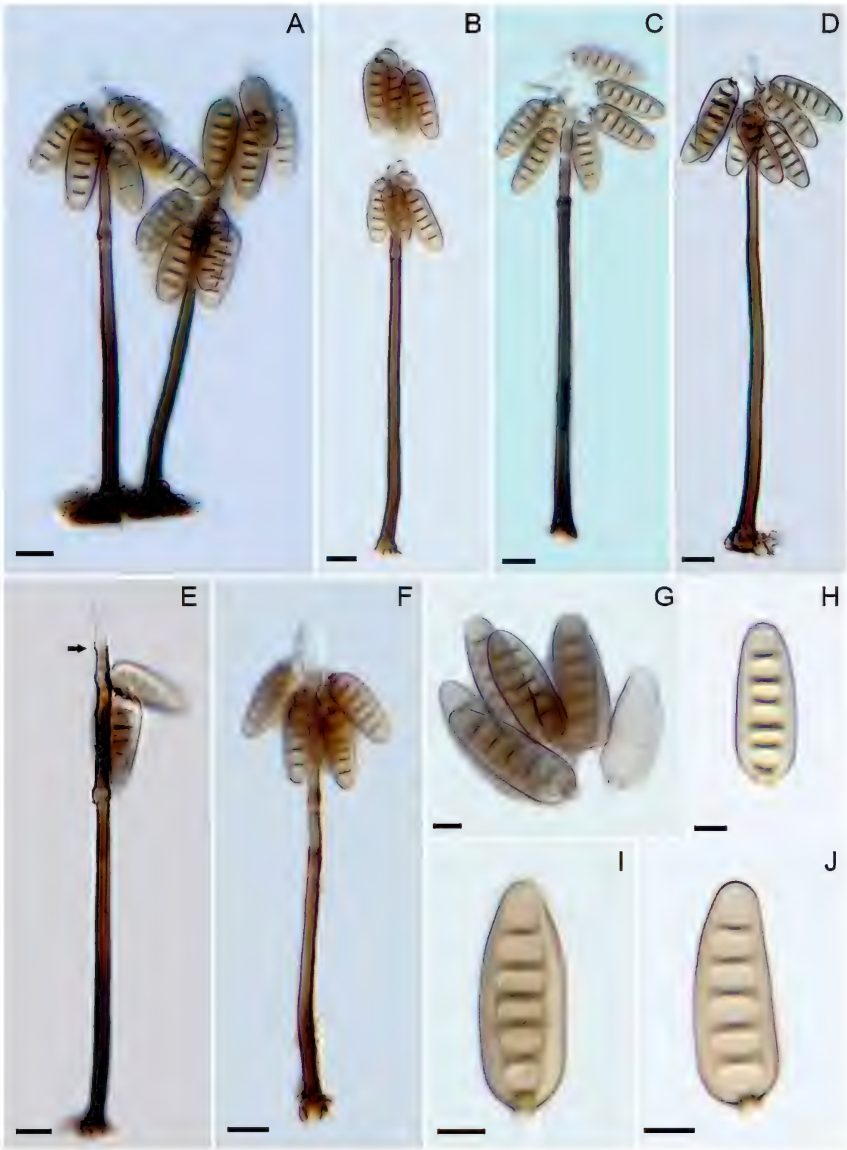


Fig. 1. *Anaexserticlava caatingae* (holotype HUEFS 173319): A–F. Conidiophores, conidiogenous cells, separating cells, and conidia. G–J. Conidia. Scale bars = 10 µm.

Additional specimen examined: **BRAZIL**, **Bahia**, Morro do Chapéu, on decaying leaves of an unidentified plant, 22.V.2008, coll. E.B. Santos (HUNEB/SB1484).

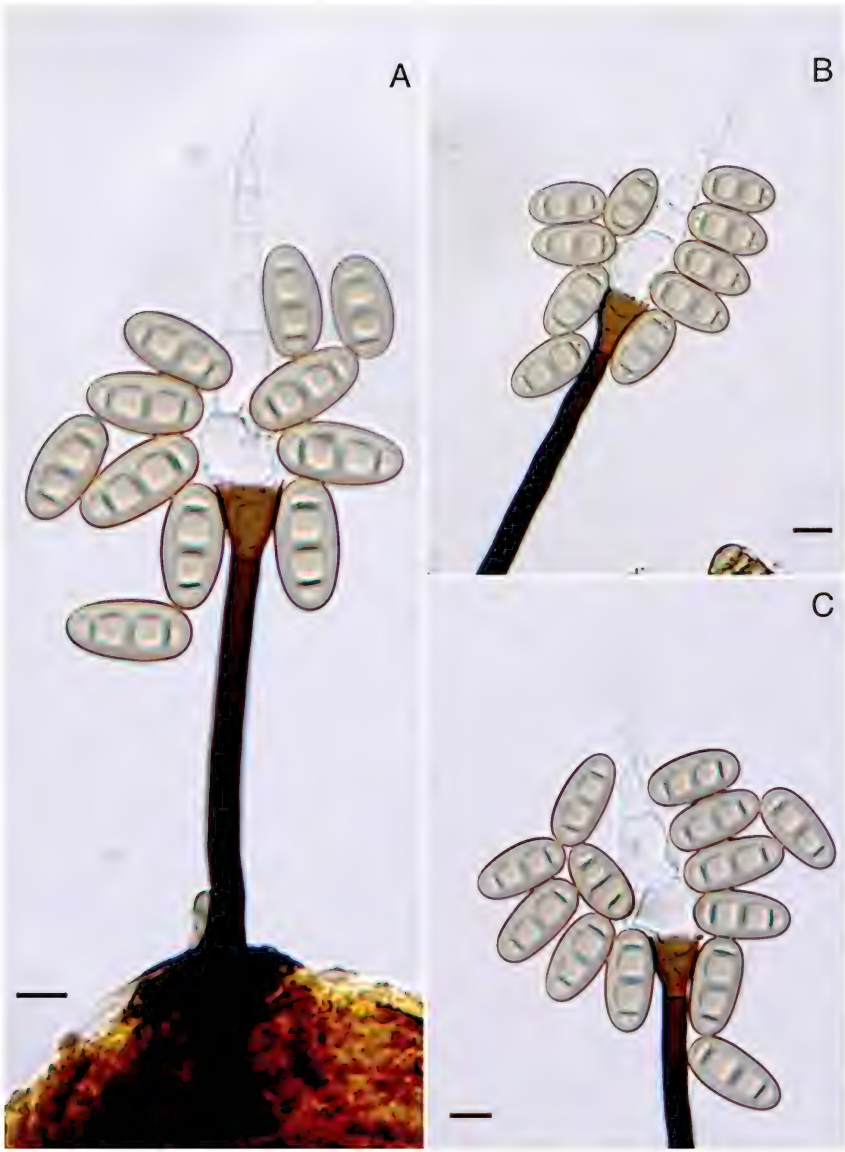


Fig. 2. *Exserticlava vasiformis* (ex HUEFS 155041): A–C. Conidiophores, conidiogenous cells, and conidia. Scale bars = 10 μm.

Note: Among the hyphomycete genera compiled by Seifert et al. (2011), only *Exserticlava* S. Hughes (Hughes 1978) has some similarities to *Anaexserticlava*,

but *Exserticlava vasiformis* (Matsush.) S. Hughes has schizolytic conidial secession and the conidia are not pedicellate at the base (Fig. 2).

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# A new species of *Endophragmiella* from Guizhou, China

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Abstract — *Endophragmiella selenosporellaria* sp. nov. was collected on dead branches of an unidentified broadleaf tree from southern China and is characterized by its branched conidiophores and *Selenosporella*-like synanamorph developed from the apical cell of the conidium. It is described, illustrated, and compared with similar species. The specimens are deposited in Herbarium of Shandong Agricultural University, Plant Pathology (HSAUP) and Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences (HMAS).

Key words — anamorphic fungi, taxonomy

## Introduction

*Endophragmiella* is a genus established by Sutton (1973) with two species, *E. pallescens* B. Sutton (the type species) and *E. canadensis* (Ellis & Everh.) B. Sutton. Hughes (1979) later emended the genus and gave a very detailed account of conidiogenesis and generic concepts, describing the genus as comprising hyperparasites with often frequently branching conidiophores and conidia that bear a distinct frill. *Endophragmiella* is mainly characterized by solitary acrogenous conidia that secede rhexolytically from monoblastic, integrated, terminal, and determinate or percurrently extending conidiogenous cells (Sutton 1973, Ellis 1976, Hughes 1979, Wu & Zhuang 2005). At present, over 90 species are accepted in the genus (MycoBank 2014, Ma et al. 2011, Ren et al. 2011). The taxonomic classification of *Endophragmiella* species is based primarily on morphological characteristics including conidial shape, size, pigmentation, septation, and presence or absence of a rostrum at the apex and the frill at the base.

During an investigation of saprobic microfungi on dead branches of Southern China, an interesting fungus with morphological features typical of *Endophragmiella* (Sutton 1973) was collected. It differs significantly from

previously described *Endophragmiella* species and is proposed here as new to science.

## Materials and methods

Samples of decaying wood were collected from subtropical forests of Guizhou province, China, placed in separate zip-lock plastic bags, taken to the laboratory, and then incubated at 27°C for more than 2 weeks in an artificial climate box in 9 cm diameter plastic Petri dishes containing moistened filter paper. Samples were examined under an Olympus SZ61 dissection microscope. All microscopic characteristics were determined on the basis of measurements of 50 mature conidia and 30 conidiophores mounted in lactophenol at 60× and 100× magnification, and photographed with an Olympus BX51 microscope.

***Endophragmiella selenosporellaria*** Y.R. Ma & X.G. Zhang, **sp. nov.** Fig. 1

MycoBank MB 812602

Differs from *Endophragmiella corticola* by its slightly smaller conidia with a subconical apical elongation and its *Selenosporella*-like synanamorph and from *E. verticillata* by its irregularly branched conidiophores.

Type: China, Guizhou Province: Mount Leigong, on dead branches of an unidentified broadleaf tree, 9 Sep. 2013, Y.R. Ma (**Holotype**, HSAUP H4320; **isotype**, HMAS 243457).

Etymology: refers to the synanamorphic *Selenosporella*-like conidia.

Colonies on the natural substrate effuse, brown. Mycelium superficial and immersed, composed of branched, septate, pale brown to brown, smooth-walled hyphae. Conidiophores macronematous, singly or in small groups, straight or flexuous, multiseptate, smooth, light brown or yellowish, paler towards the apex, determinate without percurrent proliferations, 48.5–117.5 × 3.0–4.0 μm. Branches arising more or less 45° to 50° from the main stalk, 8.5–32.5 um long, 0–2-septate. Conidiogenous cells tapered at the apex, monoblastic, terminal, integrated, slightly swollen, pale brown, subhyaline to hyaline. Conidial secession rhexolytic. Conidia solitary, acrogenous, elongated ellipsoid to obclavate, basal cell brown to dark brown, often with a small basal frill, apical cell subconical elongated, subhyaline to hyaline, (0–)2–3-septate, slightly constricted at septa, 14.5–22.0 × 4.5–6.5 μm. Synanamorph *Selenosporella*-like conidia filiform, acerose, hyaline, aseptate, 8–12 × 1.0–1.5 μm, developed from apical cell of the conidia.

Comments – *Endophragmiella selenosporellaria* possesses conidia most similar in shape to those of *E. corticola*, *E. verticillata*, *E. acuta*, *E. curvata*, and *E. cesatii*. However, *E. corticola* differs by its slightly bigger (16.5–25 × 5.5–7.5 μm) light-colored conidia without a subconical apical elongation and its lack of a *Selenosporella*-like synanamorph (Kirk 1982); *E. curvata* has predominantly 2-septate conidia and unbranched conidiophores (Hughes 1979); *E. cesatii* has wider (11–12.5 μm), predominantly 3-septate conidia with subhyaline basal cell and unbranched conidiophores (Hughes 1979); *E. acuta* has wider (8–10 μm), rostrate, predominantly 3-septate conidia (Wu & Zhuang 2005); and

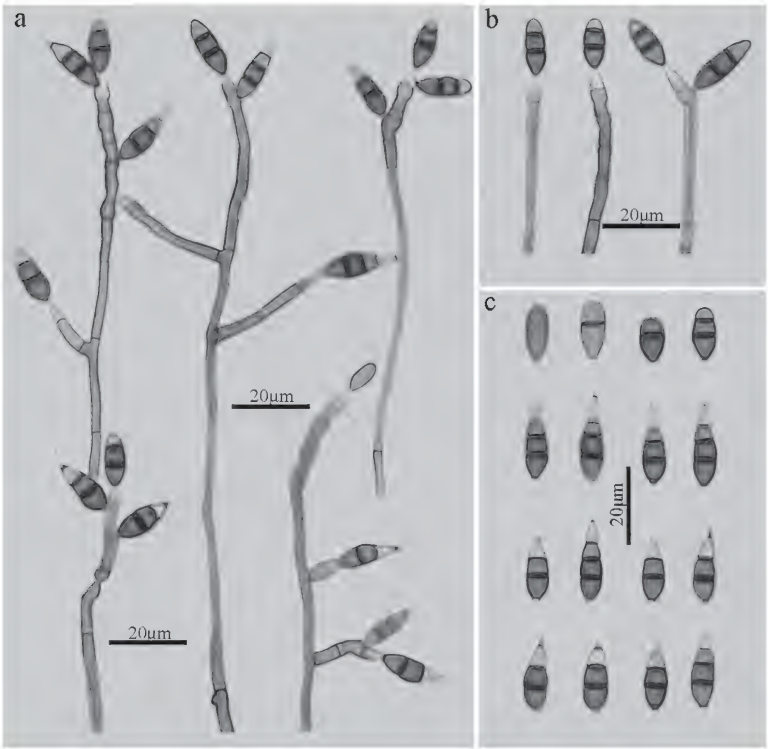


Fig. 1. *Endophragmiella selenosporellaria* (holotype, HSAUP H4320).
a. Conidiophores with conidia. b. Conidiogenous cells and conidia. c. Conidia

*E. verticillata* has shorter (12.5–16.2 μm), 3-septate (not constricted) conidia and verticillately branched conidiophores (Hughes 1978).

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The authors express gratitude to Dr. R.F. Castañeda-Ruiz and Dr. De-Wei Li for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (Nos. 31093440, 31230001) and the Ministry of Science and Technology of the People's Republic of China (Nos. 2006FY120100).

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# *Peziza succosella* and its ectomycorrhiza associated with *Cedrus deodara* from Himalayan moist temperate forests of Pakistan

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Abstract —Ascomata of *Peziza succosella* and its ectomycorrhiza associated with *Cedrus deodara* were collected from the Himalayan moist temperate forests of Pakistan. The fungal partner in the ectomycorrhiza was identified by sequencing the rDNA internal transcribed spacer region. The morphology of the taxon is also described. Ascomata are characterized by grayish brown deep cupulate apothecia while the ectomycorrhiza is characterized by a thin pseudoparenchymatous mantle with a few emanating elements. *Peziza succosella* and its ectomycorrhiza are an addition to the mycoflora of Pakistan and this is the first report of ectomycorrhizal association of *P. succosella* with Himalayan cedar.

Key words — *Cedrus deodara,* conifers, ITS, *Pezizaceae*, morphotype

## Introduction

*Peziza* Dill. ex Fr. is the largest genus within *Pezizaceae*, with approximately 100 accepted species (Kirk et al. 2008) distributed worldwide. Ten *Peziza* species have been reported from Pakistan: *P. badiofusca* (Boud.) Dennis, *P. cerea* Sowerby, *P. gerardii* Cooke, *P. michelii* (Boud.) Dennis, *P. micropus* Pers., *P. pakistanica* (S. Ahmad) S. Ahmad, *P. repanda* Wahlenb., *P. succosa* Berk., *P. vesiculosa* Bull., and *P. violacea* Pers. (Ahmad et al. 1997, Ashraf & Khalid 2012, Ashraf et al. 2012).

The genus is characterized by epigeous cupulate to discoid sessile to subsessile fleshy ascomata ranging from a few millimetres to more than 10 centimetres in diameter. The majority of the species are considered to be saprotrophs, although ectomycorrhizal species have also been reported (Maia et al. 1996, Hansen et al. 2001, Tedersoo et al. 2006, Ashraf et al. 2012, Jabeen et al. 2012, Jabeen & Khalid 2014). Generally ectomycorrhizae (EcM) of *Pezizales* possess

a thin pseudoparenchymatous mantle, infrequent radiating elements, and no clamp connections (Agerer 1991a, 2001, 2006). Rhizomorphs, if present, do not connect to the ascomata. Identification of EcM of these fungi is difficult using morphological and anatomical methods, but molecular methods have proved to be an efficient identification tool. Combining morphological-anatomical characters with molecular markers is helpful for precise identification of these fungi (Tedersoo et al. 2006, Ashraf & Khalid 2012, Ashraf et al. 2012).

Some pezizalean EcM have already been reported from Pakistan, and most are known to associate with deciduous trees (Ashraf et al. 2012, Jabeen et al. 2012, Jabeen & Khalid 2014). *Peziza succosella* has been reported previously from Israel, Denmark, and Italy (Barseghyan & Wasser 2011, Tedersoo et al. 2006, Osmundson et al. 2013). In Pakistan, the species has been collected from Himalayan moist temperate forests, which extend from Murree hills and Ayubia to Miandam at 1890 to 2500 m above sea level (a.s.l.) between subtropical pine forests and sub-alpine forests dominated by *Abies pindrow* (Royle ex D. Don) Royle, *Cedrus deodara* (Roxb. ex D. Don) G. Don, and *Pinus wallichiana* A.B. Jacks. along with some deciduous trees, notably species of *Populus*, *Quercus*, and *Salix*. *Cedrus deodara* (Himalayan cedar) is an important phytobiont for many EcM fungi (Wang & Qiu 2006, Vaario et al. 2006, Hibbett & Matheny 2009, Hanif et al. 2012). The present work is the first record of the association of *P. succosella* with Himalayan cedar and a new record of this fungus for Pakistan.

## Materials & methods

### Sampling site

Sampling was carried out during monsoon season from 2010 to 2013. Two sampling sites in Khyber Pakhtunkhwa (KPK) were selected, Khanspur, Ayubia and Sharan, Kaghan Valley. These sites are dominated by moist temperate conifer forests. The areas range from mountains with rugged valleys to undulating and dissected sub-mountain plateaus and flat mountains at 3000–4000 m a.s.l. (Khan 1999). Mean annual temperature of these sites is 10°C (Malik & Sukhera 2012), with temperatures down to 3°C curing December and January and up to 26°C during summer; mean annual rainfall is 1200 mm with 57% humidity (Ahmed et al. 2006). Soil is silt loam to silt clay and non-calcareous to slightly calcareous (Khan 2004). The pH is slightly acidic (≤7) due to high organic content (3–4%) (Irshad & Khan 2012). Among the conifers *Cedrus*, *Picea*, *Pinus*, and *Taxus* dominate, along with some deciduous tree species (Sheikh 1993).

### Collection and characterization of ascomata

Specimens were photographed using Nikon D70S digital camera in the field and were carefully removed. At least three individual fruit bodies were collected from each sampling site. Morphological features of fresh specimen were recorded, colors were designated following the Munsell Soil Color Charts (1975), and then the specimens were dried under fan heater. Specimens were sectioned and mounted on slides, and anatomical features were examined a microscope (MX4300H, Meiji Techno Co., Ltd.,

Japan). Structural components of the excipulum were studied in free hand sections and hymenial elements were studied by tearing apart a piece of hymenium using a needle. Measurements were recorded using Carl Zeiss Jena ocular micrometer and line drawing were made using Leitz Wetzlar Camera Lucida. The abbreviation n/m/p means n ascospores were measured from m ascomata and p collections. Voucher specimens were deposited in the Herbarium, Botany Department, University of the Punjab, Lahore, Pakistan (LAH).

#### Collection, isolation, and characterization of EcM

Sampling was carried out very carefully to make sure that the fine roots in the soil block belonged to the same tree. A 15-$cm^3$ soil block was dug with a shovel a few centimetres from the tree trunk. Five soil cores were taken from each sampling site. In the laboratory, each soil core was soaked in water for a few hours to loosen the soil particles and then put on a 2 mm sieve under running water to separate the roots from the soil. The EcM were carefully sorted into morphotypes under incandescent light and then under a stereomicroscope (EMZ-5TR, Meiji Techno Co., Ltd., Japan). The morphotypes were cleaned under the stereomicroscope using a fine brush. Morphologically identical morphotypes were kept in McCartney bottles in distilled water for future analysis. Replicates of these morphotypes were kept at 8°C in Eppendorf tubes containing 2% CTAB buffer for molecular analysis. Morphological characters (e.g., color, size, ramification, presence or absence of radiating elements) were noted under the stereomicroscope. Mantle layers (inner and outer) and radiating hyphae were mounted in trypan blue stain (Agerer 1991b). Hyphae were measured using an ocular micrometer and drawn using a camera lucida. A voucher specimen was deposited in LAH Herbarium.

#### DNA extraction, amplification and sequencing

For molecular analysis, up to 2 mg of ascomatal tissue was placed in one Eppendorf tube and 2–4 ectomycorrhizal root tips were placed in a separate Eppendorf tube. DNA was extracted using modified CTAB method (Bruns 1995). Internal Transcribed Spacer (ITS) regions of nuclear ribosomal DNA (nrDNA) were amplified using universal primer pair (ITS1F: 5′-CTTGGTCATTTAGAGGAAGT-3′ and ITS4: 5′- TCCTCCGCTTATTGATATGC-3′) following Gardes & Bruns (1993). The products were sent to Macrogen Inc. (Korea) for sequencing.

#### Molecular phylogenetic analysis

Consensus sequences were generated from the obtained sequences and then BLAST searched at NCBI (http://www.ncbi.nlm.nih.gov/). Sequences with the closest matches were selected from GenBank to reconstruct a phylogeny. Sequences that showed less query cover and negative E value were not included. Published sequences of the closest relatives of the species were also included in the final data set, and *Sarcosphaera coronaria* (Jacq.) J. Schröt. was chosen as outgroup (Tedersoo et al. 2006). ClustalW was used to align sequences in BioEdit software. The sequences were trimmed with the conserved motifs 5 -(...GAT) CATTA... and...GACCT (CAAA...)-3 , and the alignment portions between them was used to reconstruct phylogeny. Maximum likelihood (ML) analysis was performed using Jukes-Cantor model in MEGA6 software to test the phylogeny at 1000 bootstraps. Percentage identity and divergence in nrDNA-ITS was analysed using

MegAlign (DNAStar). Sequences generated in this study were submitted to GenBank (KM199728, KM199729).

## Taxonomy

***Peziza succosella*** (Le Gal & Romagn.) M.M. Moser ex Aviz.-Hersh. & Nemlich, Israel J. Bot. 23(3): 156 (1974). Fig. 1

Apothecia deeply cupulate, sessile to sub-sessile, circular, centrally attached, initially circular, irregular at older stage, medium-sized (1.5–2.5 cm). Hymenium smooth, olivaceous grey (10YR6/2), outer surface smooth, pale grey (5Y7/2). Asci cylindrical, operculate, unitunicate, 8-spored, uniseriate, strongly amyloid at apex, slightly narrowing towards base, 253–290 × 15–17 µm. Ascospores [50/4/2] ellipsoid, uniguttulate, light brown, ornamented, (15–)16–18 × 8–11 µm (16.93 ± 0.815 × 9.66 ± 0.59; Qm = 1.75 ± 0.12), ornamentation longitudinal warts to partially reticulate, 1.2–2.0 µm high warts. Paraphyses slender, septate near base, same diam. throughout length, same length as asci, ≤4.3–5.0 µm wide. Excipulum ectal textura globosa to textura angularis, slightly brown cells, 13–23 × 15–20 µm, globose cells of ectal smaller as compared to inner angular cells, ectal cells ending in hyphoid extensions that appear septate, hyaline, blunt ended, 8–11 µm wide.

Material examined: **PAKISTAN**, **Khyber Pakhtunkhwa**, Ayubia, Khanspur Village, 2575 m a.s.l., in Himalayan moist temperate forests, on ground, damp soil, 21 August 2010, Tayiba Ashraf; TA-135 (LAH210810); Kaghan Valley, Sharan, 2011 m a.s.l., in Himalayan moist temperate forests, 14 August 2011, Tayiba Ashraf, TA-221(LAH140811; GenBank KM199729).

### Morphological characterization of EcM Fig. 2

Ectomycorrhizal system dichotomous to coralloid, explored at upper layer of soil, ≤4 mm long, axis ≤400 µm in diameter, un-ramified ends straight, not inflated and cylindrical, ≤400 µm in diameter, width of tip base and apex 300 µm, grayish brown to dark brown or black at maturity. Mantle grayish (5Y7/2) to transparent, distinct, smooth surface, luster matte; host tissue visible under the mantle surface. Rhizomorphs absent. Emanating hyphae transparent, infrequent, sometimes frequent at few tips, straight, cylindrical rarely branched.

Material examined: **PAKISTAN**, **Khyber Pakhtunkhwa**, Ayubia, Khanspur Helipad, 2575 m a.s.l., in Himalayan moist temperate forests, mycorrhiza associated with *Cedrus deodara,* 21 September 2013, Sana Jabeen; SA116; HP-5 (LAH-EM1-2013; GenBank KM199728).

### Anatomical characteristics of mantle in plan view

Mantle pseudoparenchymatous in all layers, non-gelatinous, angular cells with blunt corners. Outer mantle layer pseudoparenchymatous, cells angular, (mantle type K, Agerer 1987–2002; Agerer & Rambold 1998), cells

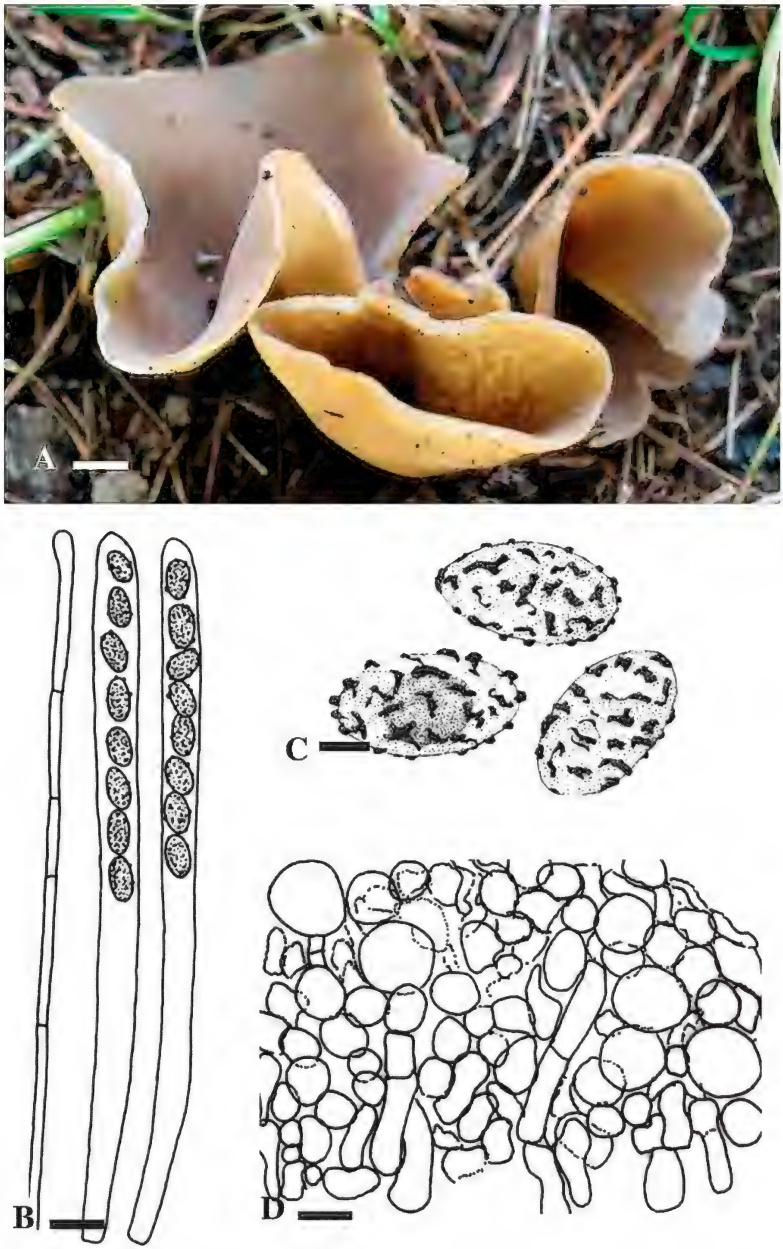


Fig. 1. *Peziza succosella* (LAH140811). A. Apothecia. B. Asci with ascospores and paraphyses. C. Ornamented ascospores. D. Part of excipulum. Scale bars: A = 1.5 cm; B, D = 25 µm; C = 5 µm.

membranaceously and plasmatically transparent, 11.56 × 10.01 ± 9.05 µm, matrix clear. Inner mantle layer pseudoparenchymatous, angular cells with blunt corners, (mantle type K, Agerer 1987–2002; Agerer & Rambold 1998), cells membranaceously and plasmatically transparent, 12.46 ×10.05 ± 10.07 µm, cell contents clear.

#### Anatomical characteristics of emanating elements

Emanating hyphae elongated, straight, cylindrical, up to 4.74 µm in diameter, wall up to 0.70 µm thick, surface smooth, hyphae septate, septa frequent, clamps absent, septa 32.70 µm apart, contents clear, ramification rather frequent, Y-shaped, anastomosing; cystidia not observed. Rhizomorphs absent.

#### Molecular Phylogenetic Characterization

Sequences of the ITS region of nrDNA of fruit body and EcM were BLAST searched at NCBI. BLAST search revealed that the subject sequences were 99% identical with *P. succosella* (JF908535) and a specimen identified as *P. subumbrina* Boud. (JF908552) from Italy with 100% and 96% query cover respectively, and 0.0 E value. Both Pakistani sequences — TA-221 (fruit body) and SA116 (EcM) — clustered with *P. succosella* from Italy and Denmark (DQ200841) with 99% boot strap support; these form a sister clade with *P. infossa* and *P. succosa* in the phylogenetic tree with 92% bootstrap support (Fig. 3). Both sequences showed a 99.8% genetic identity with *P. succosella* (JF908535), a 97.2% with the questionably identified Italian specimen of *P. subumbrina* (JF908552), and a 92.7 % genetic identity with *P. succosella* (DQ200841) from Denmark with 0 value of genetic divergence. The low value of genetic identity of *P. succosella* (DQ200841) is due to low query cover (89%) in BLAST.

## Discussion

Pezizalean species constitute an important part of mycobiont diversity in EcM fungal communities (Tedersoo et al. 2006). Many EcM fungal taxa belonging to this group have been reported from Himalayan moist temperate forests of Pakistan (Ashraf et al. 2012, Hanif et al. 2012). EcM morphology of pezizalean taxa is little studied. Previously published morphological and anatomical descriptions of pezizalean EcM cover only a few genera. EcM of *P. succosella* are grayish brown and showed dichotomous to coralloid type of ramification, presence of a pseudoparenchymatous thin mantle layer with few emanating hyphae, and lack of clamped septa. These characters are distinct from the previously reported EcM of *P. michelii* having yellow green to olive green morphotypes (Tedersoo et al. 2006) and cream white with brown to black older tips (Ashraf et al. 2012). Cells of the mantle layer of *P. michelii* differ greatly in size and shape from each other while the cells of mantle layer of *P. succosella* showed comparatively less variability in size and shape among

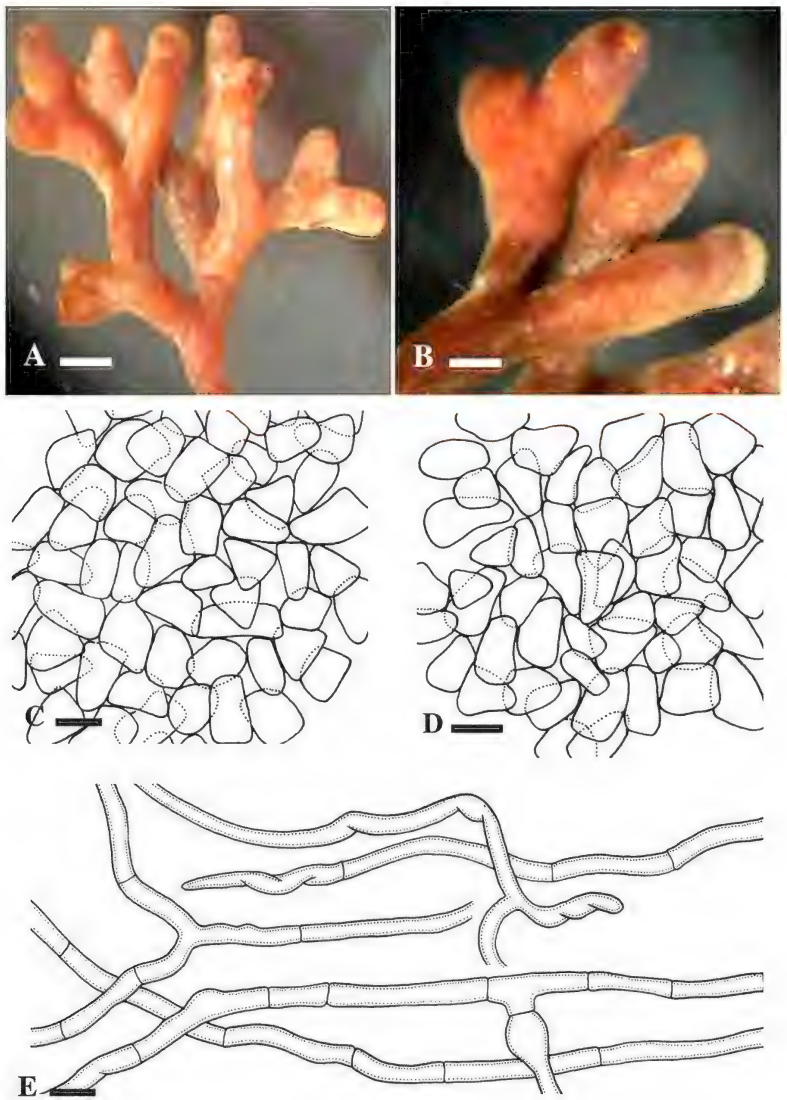


Fig. 2. EcM of *Peziza succosella*. A. Ectomycorrhizal system. B. Root tip morphology. C. Inner mantle layer. D. Outer mantle layer. E. Emanating hyphae. Scale bars: A = 0.5 mm; B = 0.25 mm; C–E = 10 μm.

themselves. Sequences of the fruit body and EcM along with morphological descriptions were found helpful in identification. ITS phylogenetic analysis revealed that the sequences derived from ascocarp and ectomycorrhizal tissue

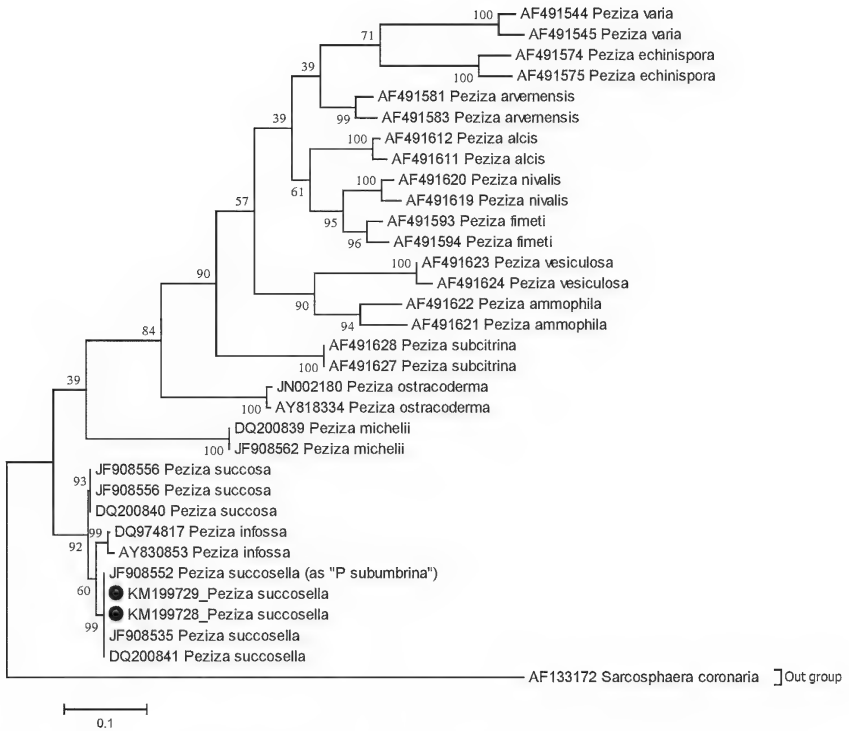


FIG. 3. Molecular phylogenetic analysis of *Peziza succosella* and related species. New sequences generated from Pakistan are marked with ●. Genbank accession numbers of all taxa are given. The percentage of trees in which the associated taxa clustered together at 1000 bootstraps is shown next to the branches. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The analysis involved 33 nucleotide sequences. There were a total of 885 positions in the final dataset.

clustered with *P. succosella* from Italy and Denmark with very strong bootstrap value. Its ectomycorrhiza has previously been undescribed. The molecular distinction among specimens from Pakistan and other countries is minimal, placing the ascocarps and EcM of *Peziza succosella* in the same species, despite the large geographic distance. This indicated a wide species distribution and a circum-Mediterranean distribution pattern.

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# *Cryptocoryneum parvulum*, a new species on *Araucaria angustifolia* (Brazilian pine)

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Abstract—*Cryptocoryneum parvulum* sp. nov., collected on decaying needle-like leaves of *Araucaria angustifolia,* is described and illustrated. It is distinguished by clavate inflated conidiophores and small cheiroid conidia with black cap cells and four pendulous arms of pale brown cells. Two other *Cryptocoryneum* species, *C. condensatum* and *C. rilstonei*, are newly recorded and illustrated. A key to *Cryptocoryneum* species found in Brazil is provided.

Key words— asexual fungi, systematics, subtropical fungi

## Introduction

During a mycological survey of fungi associated with litter at a Brazilian araucaria forest, an interesting *Cryptocoryneum* specimen was collected from decaying needle-like leaves. It showed remarkable differences from all previously described *Cryptocoryneum* species (Ellis 1971, 1976) and is therefore described here as new.

## Materials & methods

Samples of litter were placed in paper bags, taken to the laboratory, and prepared according to Castañeda-Ruiz (2005). Mounts were prepared in PVL (polyvinyl alcohol, lactic acid, and phenol) and measurements were made at a magnification of ×1000. Micrographs were obtained with an Olympus BX51 microscope equipped with bright field and Nomarski interference optics. The type specimen is deposited in the Herbarium of Universidade Estadual de Feira de Santana (HUEFS).

## Taxonomy

***Cryptocoryneum parvulum*** S.S. Silva, Gusmão & R.F. Castañeda, **sp. nov.** Fig.1

IF 550828

Differs from other *Cryptocoryneum* spp. by its inflated conidiophores and conidiogenous cells and its smaller, cheiroid conidia with dark cap cells and four pendulous, 3–4-septate, pale brown to subhyaline arms.

Type: Brazil, Rio Grande do Sul State: São Francisco de Paula, Floresta Nacional de São Francisco de Paula, 29°25 S 50°23 W, 838 m alt., on decaying needle-like leaves of *Araucaria angustifolia* (Bertol.) Kuntze (*Araucariaceae*), 27.VIII.2014, coll. S.S. Silva. (**Holotype**, HUEFS 210439).

Etymology: Latin, *parvulum*, referring to the small conidia.

Conidiomata sporodochial, pulvinate, 75–140 µm diam., scattered, black. Mycelium superficial and immersed. Hyphae septate, branched, 2.5–3 µm diam., smooth, brown. Conidiophores distinct, clavate, inflated, single, erect, straight, close packet, pale brown, 0–2-septate, smooth, 15–25 × 9⊠16.5 µm. Conidiogenous cells monoblastic, clavate to cylindrical or doliiform, integrated, terminal, determinate. Conidia solitary, acrogenous, cheiroid, branched, 12–23 × 10.5–15 µm, with black cap cells and four pendulous pale brown arms, smooth, 3–4-septate, 2.5–5 µm wide.

Note: *Cryptocoryneum* Fuckel (Ellis 1971, 1976, Schoknecht & Crane 1977) is characterized by monoblastic conidiogenous cells, and cheiroid conidia composed of a series of dark brown cap cells from which the pendulous arms develop.

## Additional *Cryptocoryneum* records from Brazil

***Cryptocoryneum condensatum*** (Wallr.) E.W. Mason & S. Hughes ex S. Hughes, Can. J. Bot. 36: 758 (1958). Fig. 2 A–D

Specimen examined: **BRAZIL, Rio Grande do Sul State**, São Francisco de Paula, Floresta Nacional de São Francisco de Paula, 29°25 S 50°23 W, 838 m alt., on decaying needle-like leaves of *Araucaria angustifolia*, 29.IX.2014, coll. S.S. Silva (HUEFS 210440).

Note: A new record for Brazil.

***Cryptocoryneum rilstonei*** M.B. Ellis, Mycol. Pap. 131: 2 (1972). Fig. 2 E–H

Specimen examined: **BRAZIL, Rio Grande do Sul State**, São Francisco de Paula, Floresta Nacional de São Francisco de Paula 29°25 S 50°23 W, 838 m alt., on decaying needle-like leaves of *Araucaria angustifolia*, 21.VIII.2014, coll. S.S. Silva (HUEFS 210441).

Note: A new record for Brazil.

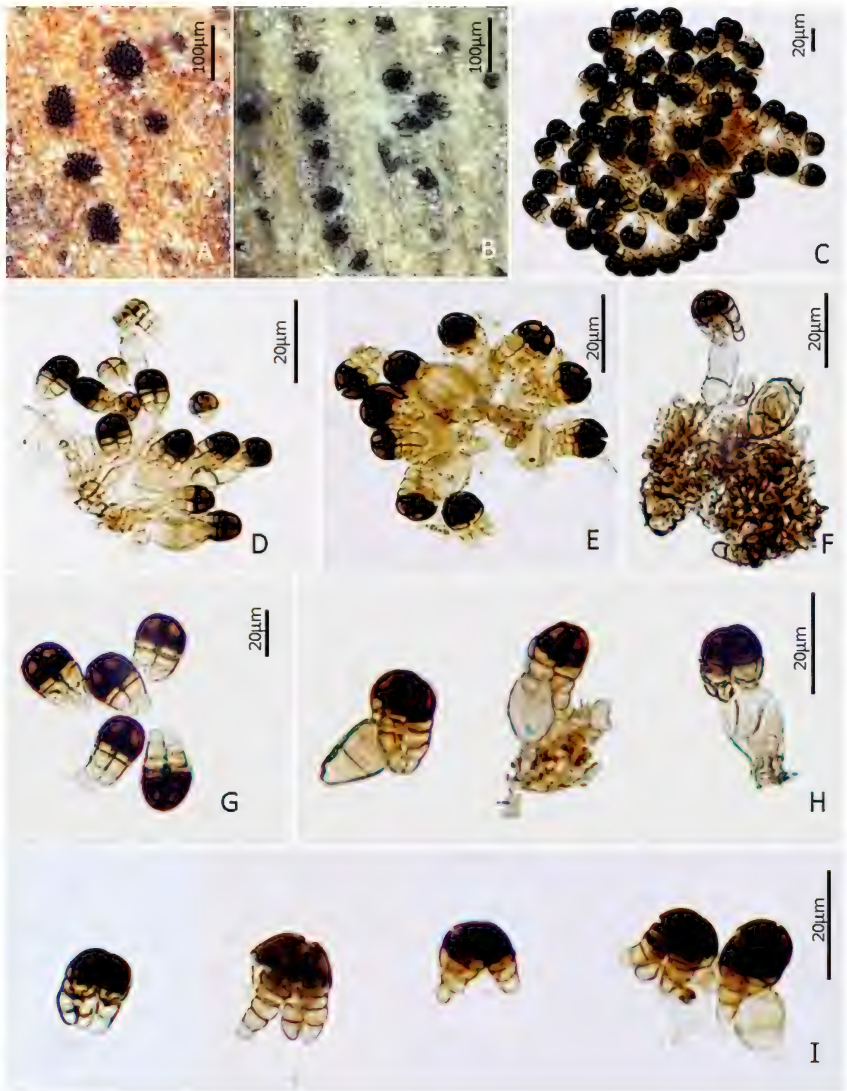


Fig. 1. *Cryptocoryneum parvulum* (holotype, HUEFS 210439): A–B. Sporodochia on natural substrate. C–E. Sporodochia. F. Conidiophores, conidiogenous cells and conidia. G–H. Conidiogenous cell and conidia. I. Conidia.

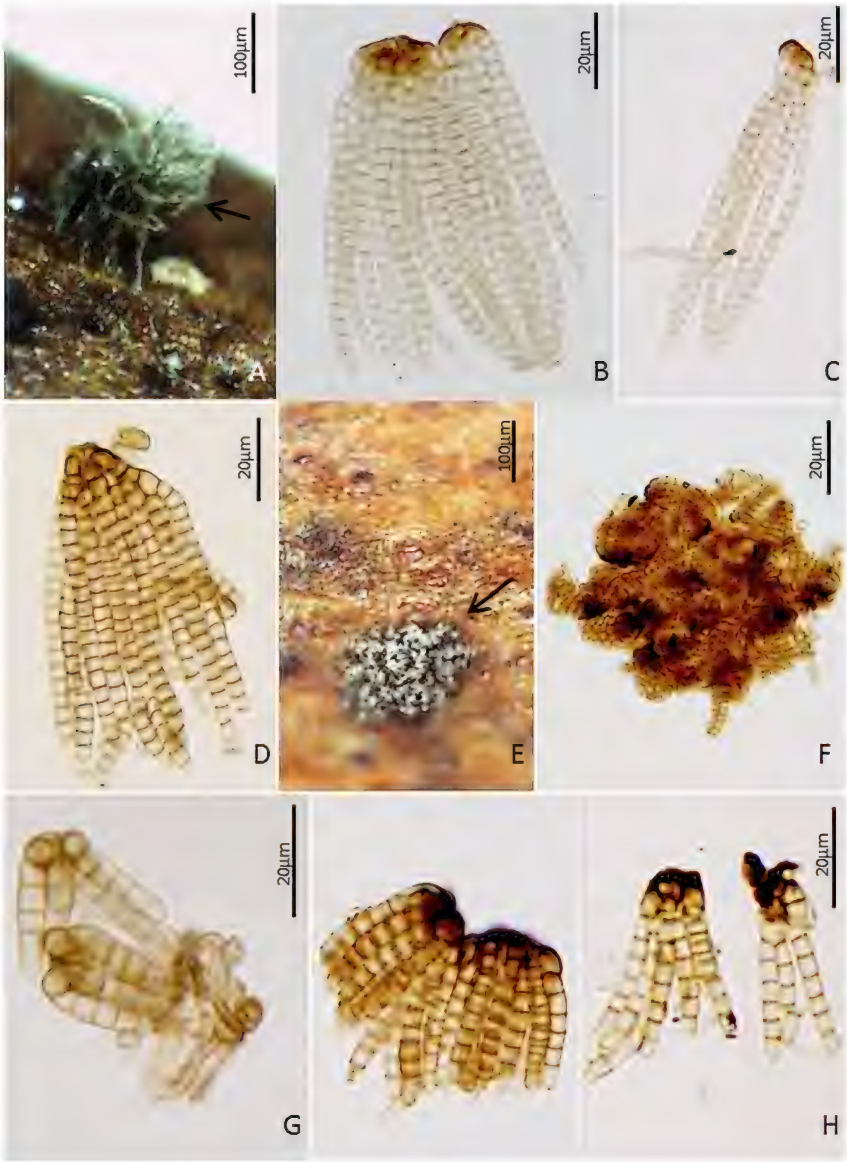


Fig 2. ***Cryptocoryneum condensatum*** (HUEFS 210440): A. Sporodochium on the natural substratum. B–D. Conidia. ***Cryptocoryneum rilstonei*** (HUEFS 210441): E. Sporodochium on the natural substratum. F. Sporodochium. G–H. Conidia.

**Key to *Cryptocoryneum* species found in Brazil**

1. Conidiophores cylindrical ..... 2
1. Conidiophores clavate, inflated, 15–25 µm long; conidia 12–23 × 10,5–15 µm, with dark cap cells and 4 pendulous pale brown arms, 3–4-septate, 2.5–5 µm wide ..... *C. parvulum*
2. Conidiophores ≤90 µm long; conidia 40–85 × 20–35 µm, with 6–14 pendulous pale brown to yellowish brown or subhyaline arms, 15–20-septate, 2.5–4.5 µm wide ..... *C. condensatum*
2. Conidiophores ≤45 µm long; conidia 20–45 × 12–30 µm, with 3–9 pendulous subhyaline or pale brown arms, 3–9-septate, 4–6 µm wide ..... *C. rilstonei*

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# Two new species and a new record of *Leptogium* from China

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Abstract — *Leptogium taibaiense* sp. nov. and *L. wangii* sp. nov. both have short hairs composed of cylindrical cells on their lower surfaces and are glabrous and smooth on their upper surfaces. *Leptogium burgessii* is a new record for China.

Key words —taxonomy, *Ascomycota*, *Peltigerales*, *Collemataceae*

## Introduction

Thirty-nine species of the lichen genus *Leptogium* (Ach.) Gray have been reported in China, among which 18 hairy species were recorded in Mainland China (Wei 1991, Wang et al. 2010, Liu & Guan 2012, Liu et al. 2012, Cao et al. 2012, Xi & Liu 2014). A recent collection of a short-haired *Leptogium* from Beijing did not correspond with any named species and is described here as a new species, *L. wangii*. Other herbarium specimens of short-haired *Leptogium* species studied were found to represent a second new species, described here as *L. taibaiense*, and a new record for China, *L. burgessii*.

## Materials & methods

A dissecting microscope (Motic SMZ-140) and light microscope (Motic B2) were used for the morphological and anatomical studies. Photographs were taken with BX51 fluorescence microscope. The type specimens of *Leptogium taibaiense* and *L. wangii* are deposited in Herbarium Mycologicum Academiae Sinicae–Lichenes, Beijing, China (HMAS-L). Other specimens are deposited in HMAS-L or Herbarium of Kunming Institute of Botany, Academia Sinica, Kunming, China (KUN).

## Taxonomy

***Leptogium taibaiense*** H.J. Liu & M.Q. Xi, **sp. nov.** Pl. 1A–E

MycoBank MB 809221

Differs from *Leptogium puberulum* by its horizontal, entire, broader lobes and its corticolous habitat.

Type: China. Shaanxi Province, Mt. Taibai, Temple Ping'ansi, 34°01′N 107°48′E, elev. 2700 m, on bark, 8/VI/1963, Jiang-Chun Wei 2604-1 (**Holotype**, HMAS-L 045039).

Etymology: The species is named after the type locality, Mt. Taibai, Shaanxi, China.

Thallus foliose, 5–6 cm in diam.; upper surface grey green in most parts when dry, especially near margin, other portions grey-blue to darker, glabrous, smooth, partially minutely striate, matt; lobes orbicular, 5–10 mm wide, flat, horizontal, the margins entire, downturned; isidia and lobules absent; lower surface paler, densely hairy, velvety, insertion of apothecia making distinctive depressions; hairs 25–50 µm long, composed of a row of cylindrical cells. Apothecia common, ± dense, laminal to submarginal, sessile to subpedicellate, 0.2–0.5 mm in diam.; disc plane to convex, dark red-brown; thalline exciple thin, glabrous, smooth, concolorous with the thallus or slightly paler.

Thallus 100 µm thick; cortex on both sides consisting of a single layer of subglobose, isodiametrical cells, 4–5 µm in diam.; photobiont *Nostoc* in chains, spherical, 4–6 µm in diam.; hyphae regularly interwoven. Apothecia 420–440 µm thick; thalline exciple c. 80 µm thick at margin, with a cortex of a single layer of subglobose cells 4–6 µm in diam., and an algal layer of loosely interwoven hyphae; proper exciple subparaplectenchymatous to somewhat euthyplectenchymatous at margin, 10–20 µm thick, but indistinct or sometimes euthyplectenchymatous in center; hymenium 130–140 µm high; subhymenium 30–40 µm high; spores 8 per ascus, submuriform, ellipsoid, 18–25 × 8–12 µm, 3–4-septate transversely, 1-septate longitudinally.

Corticolous.

Remarks: *Leptogium taibaiense* is characterized by a combination of 1) the glabrous and smooth upper surface and 2) the velvety lower surface with short hairs composed of a row of cylindrical cells. Only three other species — *L. puberulum* Hue, *L. velutinum* P.M. Jørg., *L. wangii* (newly described, below) — have these characteristics. *Leptogium puberulum* differs from the new species by its ascending to erect, marginally sinuous, narrower (2–5 mm) lobes, its lack of proper exciple, its wider (14–16 um) spores, and its rock and soil substrate (Dodge 1973, Øvstedal & Smith 2001). *Leptogium velutinum* differs by its bluer upper surface, pedicellate apothecia, and larger spores (30–50 × 14–19 µm; Jørgensen 1997). *Leptogium wangii* (see below) differs by its pulvinate thallus, often concave and narrower (3–5 mm wide) lobes with sinuous and upturned

margins, tomentose thalline exciple, euparaplectenchymatous proper exciple, and substrate of soil covered rocks.

***Leptogium wangii*** H.J. Liu & J.S. Hu, sp. nov. Pl. 1f–j

MycoBank MB 809222

Differs from *Leptogium velutinum* by its narrower lobes, sessile apothecia, and smaller spores.

Type: China. Beijing City, Xiaolongmen National Forest Park, 39°57′N 115°26′E, elev. 1100 m, on soil covered rocks, VII/2013, Jian-Bin Chen & Xiao-Di Liu 2013-0714 (**Holotype**, HMAS-L 129380).

Etymology: This species is named in honor of Li-Song Wang M.Sc., a lichenologist who made numerous *Leptogium* collections from southwestern China.

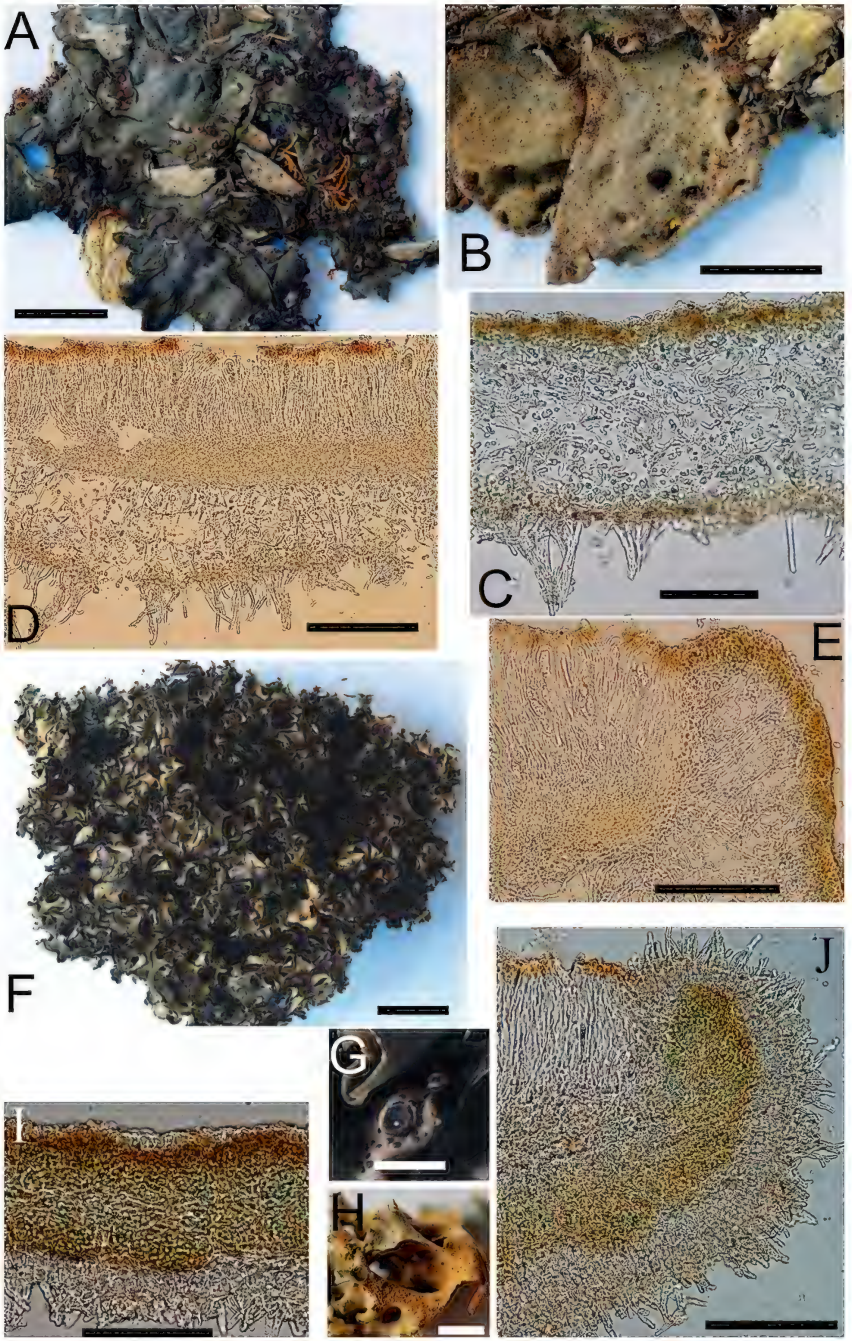
Thallus foliose, circular in outline, 5–6 cm in diam., pulvinate; upper surface grey-blue to brown when dry, glabrous, smooth to partially slightly striate, without wrinkles, dull; lobes 3–5 mm wide, often sub-erect, concave to sometimes flat, the margins sinuous, upturned; isidia and lobules absent; lower surface paler, velvety, densely hairy; hairs white, (25) 40–60 (70) µm long, composed of a row of cylindrical cells. Apothecia rare, laminal, 0.5 mm in diam., sessile; disc plane to concave, dark red-brown; thalline exciple smooth, white-tomentose, paler than the thallus.

Thallus 110–130 µm thick; cortex on upper side c. 10 µm thick, consisting of 1–2 layers of subglobose to ± elongated, isodiametrical cells, on lower side c. 20 µm thick, consisting of 2–3 layers of subglobose to ± elongated, isodiametrical cells; photobiont *Nostoc* in chains, spherical, 4–6 µm in diam.; hyphae closely regularly interwoven.

Apothecia 300–350 µm thick; thalline margin 50–60 µm thick, with a cortex of 3–5 layers of subglobose to ellipsoid cells; hymenium 130 µm high; subhymenium 20–30 µm high; proper exciple euparaplectenchymatous at margin, consisting of 3–5 layers of subglobose to ellipsoid cells, 40–60 µm thick, but often poorly developed and difficult to discern in center; lower cortex below the apothecium 70–80 µm thick, euparaplectenchymatous, consisting of 6–8 layers of subglobose to ellipsoid cells; asci clavate, 8-spored; spores submuriform, ellipsoid, 18–25 × 8–11 µm, 3 septate transversely, 1-septate longitudinally, obtuse to slightly acute at both ends.

On soil-covered calciferous rocks.

Remarks: *Leptogium wangii* is characterized by 1) a sub-erect, pulvinate thallus; 2) a smooth, glabrous, and often concave upper surface; 3) sinuous, ascending lobe margins; 4) short, cylindrical celled hairs on the lower surface; 5) a white tomentose apothecial margin; and 6) its habitat: soil- covered rocks. In habitus the new species closely resembles *L. puberulum*, which differs by its glabrous thalline exciples, broader spores (14–16 um wide), and absence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of proper exciple (Dodge 1973, Øvstedal & Smith 2001). It also resembles *L. velutinum*, which differs by its wider lobes (up to 20 mm), stalked apothecia, and larger spores (30–50 × 14–19 µm; Jørgensen 1997). For its differences from *L. taibaiense*, see remarks above.

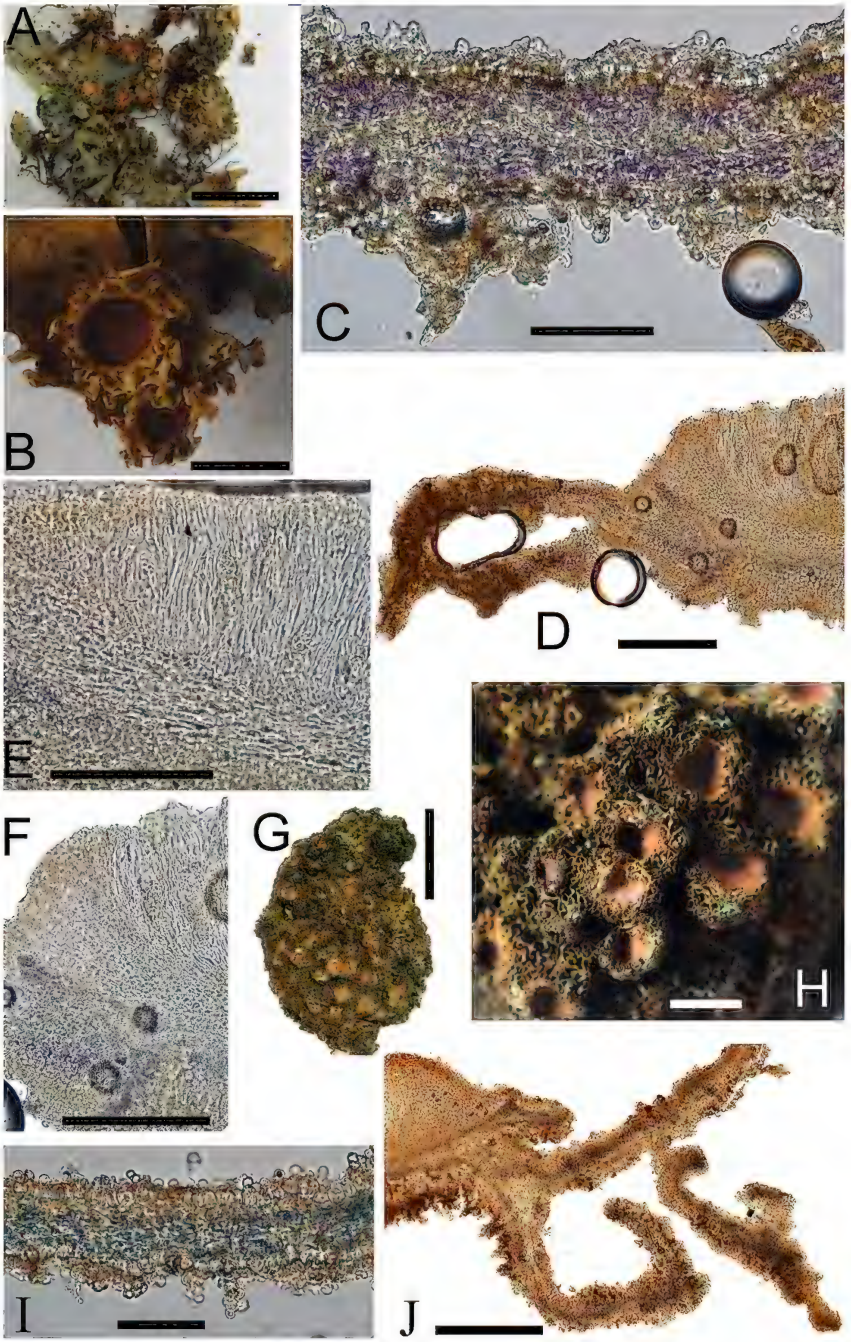
***Leptogium burgessii*** (L.) Mont., Hist. Nat. Iles Canar. 3(2): 130 (1840). Pl. 2

Thallus foliose, 4–7 cm in diam., circular or irregular in outline; upper surface grey-blue, dark grey-blue to brown when dry, glabrous, smooth, dull; lobes horizontal, or often suberect, branched, 2–5 mm wide, rapidly narrowing towards margin, the margins sinuous, wavy, entire to microphylline; lower surface paler, densely hairy; hairs white, 10–25 um long, composed of a chain of spherical cells. Apothecia few to abundant, laminal to submarginal, 0.5–5 mm in diam., sessile to subpedicellate; disc plane to concave, red-brown or darker; thalline exciple concolorous with the thallus, microphylline; microphylls free, abundant, occasionally fused at base in part and giving the thalline exciple a "collar" appearance (as in HMAS-L 032520; Fig. 2H), or only 1 or 2 whorls, not forming a "collar" (as in KUN 4846; Fig. 2B).

Thallus 50–120 µm thick; upper cortex of a single layer of subglobose, isodiametrical cells, 5–10 µm in diam.; lower cortex similar to upper cortex, 8–12 µm thick; photobiont *Nostoc* in chains, spherical, 3–7 µm in diam.; hyphae closely regularly interwoven. Apothecia 400–500 µm thick; thalline exciple euparaplectenchymatous, at the margin consisting of 2–5 layers of subglobose to ellipsoid cells, 50–60 µm thick, medullary tissues thin or absent, at the base with 6–12 layers of subglobose to ellipsoid, thin-walled cells, 110–150 µm thick; proper exciple euparaplectenchymatous and continuous with the thalline exciple laterally, consisting of 3–4 layers of subglobose to ellipsoid cells, 40 µm thick, soon becoming subparaplectenchymatous towards center and often indistinct basally; hymenium 130–200 µm high; subhymenium 30–40 µm high; asci clavate, 8-spored; spores submuriform, ellipsoid, 20–32 × 10–15 µm, 5–6 septate transversely, 1–2-septate longitudinally, obtuse at both ends.

Corticolous.

Plate 1 (left). ***Leptogium taibaiense*** (HMAS-L 045039). A. Thallus with apothecia. B. Lower side of the thallus, showing depressions made by the insertion of apothecia, and short hairs. C. Thallus cross-section, showing single-layered cortex on both sides, and short hairs on lower side. D. Apothecium cross-section. E. Cross-section of apothecial margin, showing corticated thalline margin, marginally subparaplectenchymatous proper exciple, asci and spores. ***Leptogium wangii*** (HMAS-L 129380). F. Thallus, showing the suberect to erect lobes. G. An apothecium with tomentose apothecial margin. H. Lower side, showing the short hairs. I. Thallus cross-section, showing cortex, and short hairs on lower side. J. Apothecial cross-section, showing proper exciple and the corticated thalline exciple. Scale bars: A, F = 1 cm; B = 5 mm; C = 50 µm; D, E, I, J = 100 µm. G = 1 mm; H = 0.5 mm.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Specimens examined: **China. Yunnan Province**, Lijiang City, Yulong Snow Mountain, 27°05′N 100°10′E, on bark, elev. 2400 m, 24/XII/1964, J.C. Wei 2744 (HMAS-L 032520). **Sichuan Province**, Miyi County, Malong, Mt. Beipo, 26°58′N 101°50′E, on bark, elev. 3200 m, 7/VII/1983, L.S. Wang 83-846 (KUN 4846).

Remarks: *Leptogium burgessii* is a widespread species, known from South and North America, Europe, Macaronesia, Africa, New Zealand, and India (Sierk 1964, Awasthi & Akhtar 1977, Swinscow & Krog 1988, Galloway 1999, Jørgensen & Nash 2004, Aragón et al. 2005). It is new to China.

The species is characterized by smooth upper surface, short hairy lower surface, microphylline apothecial margins, and euparaplectenchymatous thalline exciples. *Leptogium mantiqueirense* Kitaura & Marcelli, *L. digitatum* (A. Massal.) Zahlbr., and *L. marginellum* (Sw.) Gray have microphylline appendages on the thalline margins, but can be easily separated from *L. burgessii* by their distinctly wrinkled upper surfaces. *Leptogium aucklandicum* Zahlbr. also has occasional microphylline outgrowths on the thalline exciples (Galloway 1999) but differs by its glabrous lower surface.

In the smooth upper surface, microphylline to entire lobe margins, and microphylline and euparaplectenchymatous thalline exciples, our specimens of *L. burgessii* are similar to those from most literatures, especially those from the Greater Sonoran Desert regions of the US (Jørgensen & Nash 2004). In the euparaplectenchymatous proper exciple they resemble the type of *L. inflexum* Nyl. (= *L. burgessii*; see Kitaura & Marcelli 2013). However, the Chinese materials have smaller spores than those from the Greater Sonoran Desert Region (25–50 × 14–22 μm; Jørgensen & Nash 2004), from India (25–45 × 12–16 μm; Awasthi & Akhtar 1977), and from Mexico (30–38 × 12–18 μm, type of *L. inflexum*; Kitaura & Marcelli 2013) and have larger spores than those from New Zealand (20–25 × 7.5–10 μm; Galloway 1999).

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Plate 2 (left). ***Leptogium burgessii* (KUN 4846)**. A. Thallus with apothecia. B. Apothecia with microphylls. C. Thallus cross-section, showing corticated surfaces, and short hairs composed of globose cells on lower side. D. Vertical section of apothecium, showing microphylls on apothecial margin. E. Vertical section of the apothecium showing proper exciple euparaplectenchymatous at margin and subparaplectenchymatous towards center. F. Vertical section of thalline margin showing the connecting thalline and proper exciples. **(HMAS-L 032520)**. G. Thallus with apothecia. H. Apothecia with abundant microphylls on margin. I. Thallus cross-section, showing single-layered cortex on both sides, and short hairs composed of a row of globose cells on lower side. J. Vertical section of apothecium, showing microphylls on apothecial margin. Scale bars: A = 1 cm; B = 2 mm; C–F, I = 100 μm; G = 2 cm; H = 5 mm; J = 200 μm.

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# *Digicatenosporium polyramosum*, a new hyphomycete from Brazil

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Abstract—*Digicatenosporium polyramosum* gen. & sp. nov., collected on the decaying bark of an unidentified dicotyledonous plant in Bahia, Brazil, is described and illustrated. This species is unique in its distinct unbranched conidiophores, monoblastic integrated determinate conidiogenous cells, and highly digitate branched blastocatenate reddish to yellowish brown or brown conidia.

Key words— asexual fungi, systematics, tropical fungi

## Introduction

During a mycological survey of fungi associated with leaf litter in the Brazilian Caatinga biome at Coribe, Bahia State, an interesting fungus was collected from the decaying bark of an unidentified dicotyledonous plant. It showed remarkable differences from all previously described hyphomycete genera (Seifert et al. 2011) and is here proposed as a new genus and species.

## Materials & methods

Samples of submerged litter were placed in paper and plastic bags, taken to the laboratory, and prepared according to Castañeda-Ruiz (2005). Mounts were prepared in PVL (polyvinyl alcohol, lactic acid, and phenol), and measurements were made at a magnification of ×1000. Photomicrographs were obtained with an Olympus BX51 microscope equipped with bright field and Nomarski interference optics. The type specimen is deposited in the Herbarium of Universidade Estadual de Feira de Santana, Bahia, Brazil (HUEFS).

## Taxonomy

***Digicatenosporium*** S.M. Leão, Gusmão & R.F. Castañeda, **gen. nov.**

MycoBank MB810773

Differs from *Digitodesmium* by its distinct conidiophores and branched blastocatenate conidia.

Type species: *Digicatenosporium polyramosum* S.M. Leão et al.

Etymology: From the Latin: *digi-* (from *digitatus* for finger shaped) and *-catenosporium* for the conidia in chains.

Asexual fungi. Colonies on natural substratum hairy to granulose, ferruginous or reddish brown. Mycelium mostly immersed. Conidiophores distinct, single, unbranched, erect, septate, pale brown. Conidiogenous cells monoblastic, integrated, terminal, determinate; conidial secession schizolytic. Conidia digitate or cheiroid, acrogenous, reddish brown to yellowish brown, verruculose, central arms closely packed, marginal arms divergent, aseptate or euseptate, subulate to slightly obclavate, some blastocatenate at the apex.

***Digicatenosporium polyramosum*** S.M. Leão, Gusmão & R.F. Castañeda, **sp. nov.**

MycoBank MB810774 Fig. 1

Differs from *Digitodesmium* spp. by having distinct conidiophores and complex blastocatenate conidia.

Type: Brazil, Bahia, Coribe, Serra do Ramalho, 13°62′S 44°37′W, 600–800 m alt., on decaying bark of an unidentified dicotyledonous plant, 4 March 2008, coll. S.M. Leão-Ferreira (**Holotype**: HUEFS 210443).

Etymology: From the Greek *poly-* for many, numerous and the Latin *–ramosum* for branched.

Colonies on natural substratum hairy to granulose, ferruginous or reddish brown. Mycelium mostly immersed. Conidiophores distinct, single, unbranched, erect, cylindrical, 1–2-septate, smooth, 15–40 × 3–6 µm, pale brown. Conidiogenous cells monoblastic, cylindrical, integrated, terminal, determinate; conidial secession schizolytic. Conidia acrogenous, digitate or cheiroid, with 6–35 arms, overall 20–75 × 15–40 µm, basal cells cuneiform, 5–6 × 3–7 µm, reddish brown to yellowish brown to brown, arms paler above, verruculose, cylindrical, subulate to slightly obclavate, 0–4-septate, yellowish brown to reddish brown below, paler above, individually 15–30 × 5–8 µm; central arms cylindrical, closely packed, loosely incurved or parallel, dark reddish brown or brown; marginal arms divergent, often producing an apical secondary conidium, which may later repeatedly undergo the same process, producing a complex chain.

Note: *Digicatenosporium* superficially resembles *Digitodesmium* P.M. Kirk (Kirk 1981), but *Digitodesmium* has solitary conidia that have several to many

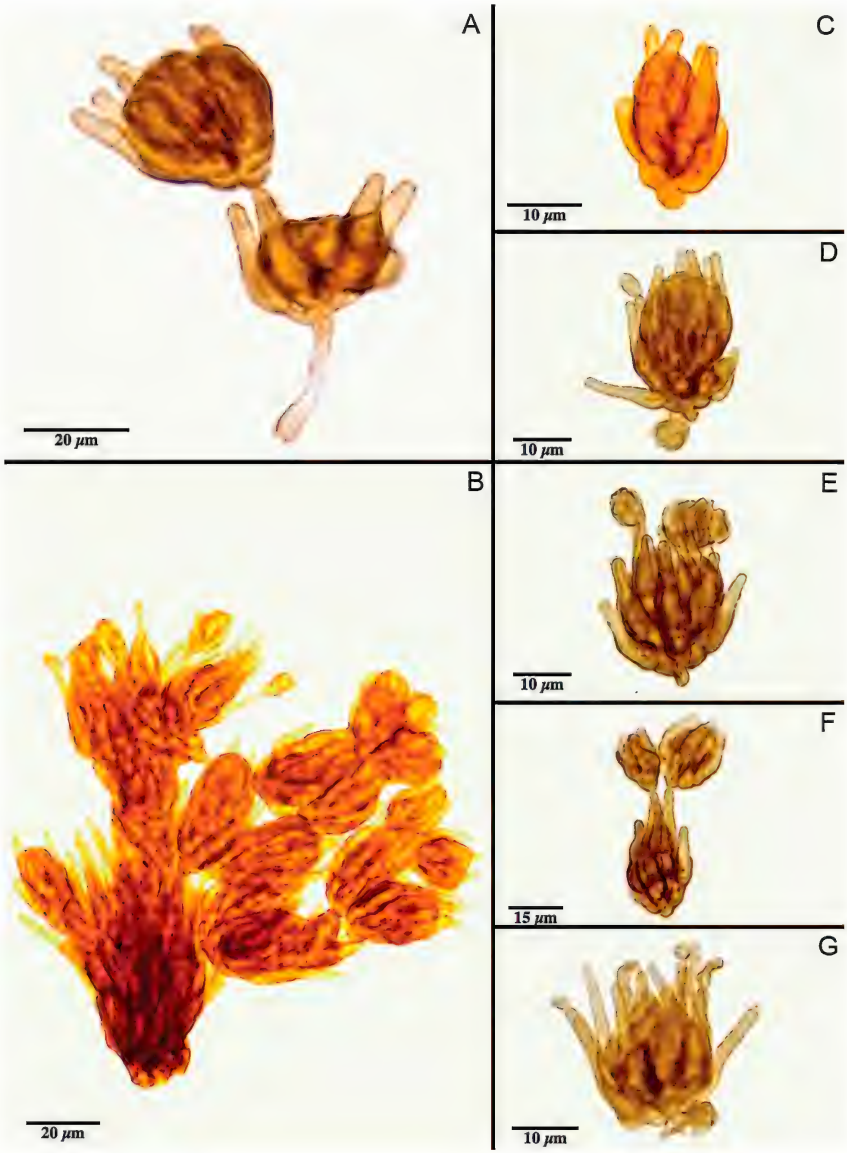


Fig. 1. *Digicatenosporium polyramosum* (HUEFS 210439). A. Conidiophore, conidiogenous cell, and conidia. B. Conidia in branched chains. C–G. Conidia and secondary conidia.

parallel cylindrical multiseptate arms. *Digicatenosporium* exhibits an unusual method for developing conidial chains in that only the apical cells of a random number of the longer marginal arms produce a secondary conidium from the original conidia while repetitions of this event at higher levels produce complex branched chains.

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# *Duportella lassa* sp. nov. from Northeast Asia

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Abstract — *Duportella lassa* is described based on 15 collections from East Siberia and Russian Far East. The new species is characterized by its monomitic hyphal structure, brown-colored lamprocystidia, and habit on dead branches (both attached and recently fallen) of angiosperm trees and shrubs.

Key words — *Basidiomycota*, *Peniophora*, *Russulales*, taxonomy

## Introduction

*Duportella* Pat. (*Russulales*, *Basidiomycota*) is a small genus of the so-called corticioid fungi currently including 13 species, mostly with tropical distribution (Andreasen & Hallenberg 2009, Hjortstam & Ryvarden 2004). Only two species of the genus, *D. halimi* (Boidin & Lanq.) Hjortstam and *D. malenconii* (Boidin & Lanq.) Hjortstam, have been reported from temperate or subtropical areas of the northern hemisphere (Boidin & Lanquetin 1974, 1977; Chamuris 1987; Duhem 1990). During the field trips in Khabarovsk Reg., Russian Far East, in 2011–14, the first author collected 14 specimens of an unknown *Duportella* species, and an older specimen from Siberia was found in mycological herbarium of Botanical Museum, University of Helsinki (H). It is described below as a new species, *D. lassa*.

## Materials & methods

The specimens studied are kept in the herbaria of the Botanical Museum, University of Helsinki, Finland (H), and the Mycological Herbarium of the Department of Biology, Geosciences and Environmental Education, University of West Bohemia, Czech Republic (KBI). The microscopic routine followed Miettinen et al. (2006) and DNA analytical methods followed Spirin et al. (2013). Measurements were done in Cotton Blue using phase contrast illumination and oil immersion (with a subjective accuracy

of 0.1 µm; Miettinen et al. 2006). Abbreviations used in the species descriptions (and calculated for each specimen measured) include L – mean spore length; W – mean spore width; Q' – spore length/width ratio; Q – mean spore length/width ratio.

## Taxonomy

Two specimens of *Duportella lassa* (Spirin 5498, 6129) were sequenced with very similar results, and we found no identical or essentially close sequences in GenBank. However, their ITS regions show up to 95% homology with some *Peniophora* species, thus displaying a vague generic status for *Duportella* versus *Peniophora* Cooke and supporting the same result shown in the complex molecular study of Boidin et al. (1998). Although more data are needed to resolve the phylogenetic relationships between the two taxa, for pragmatic reasons we here accept *Duportella* as an independent genus distinguishable by its brown-colored cystidia and hyphae and variably shaped basidiospores (versus *Peniophora* s. str.) as well as its lack of dendrohyphidia (versus *Dendrophora* (Parmasto) Chamuris); Andreasen & Hallenberg 2009).

***Duportella lassa*** Spirin & Kout, **sp. nov.** PLATES 1–3

MYCOBANK MB 808096

D. halimii *similis, sed basidiosporis minoribus.*

TYPE: Russia, Khabarovsk Reg., Komsomol'sk Dist., Boktor, on fallen decorticated branch of *Quercus mongolica* Fisch. ex Ledeb., 18 Aug 2013, Spirin 6129 (**Holotype**, H; **isotype**, KBI; GenBank KJ509191).

ETYMOLOGY: *lassus* (Lat., adj.): exhausted, tired; referring to the rarely found spores in most collections of this species.

BASIDIOCARPS perennial, resupinate, covering 1–5(–10) cm, 0.05–0.15 mm thick, first soft and waxy, then rather tough. HYMENIAL SURFACE smooth, in juvenile basidiocarps bright ochraceous, continuous, in perennial specimens ochraceous-brown, cracking with small irregular fissures (rimose), sometimes with occasional low tubercles, in senescent withered basidiocarps fading to pale brown. Margin adherent, narrow, slightly paler than hymenial surface, in older basidiocarps indistinct. Subiculum indistinct.

HYPHAL STRUCTURE monomitic; hyphae with clamps. Subicular hyphae hyaline to brownish, thin- or slightly thick-walled, more or less parallel, some tortuous and short-celled, 3–5(–6) µm in diam., in older basidiocarps producing a distinct layer 15–20 µm thick. Subhymenial hyphae thin- to slightly thick-walled, first hyaline, then brownish, irregularly and rather densely arranged, tortuose, in subhymenium short-celled, mostly 3–4 µm in diam. LAMPROCYSTIDIA abundant, brownish to dark-brown, thick-walled, apically strongly encrusted, ampullaceous or bottle-shaped, sometimes bifurcate, in older specimens with 1–2 secondary septa in the middle part, 19–36 × 3–7 (–8) µm. GLOEOCYSTIDIA thin-walled or with thickened walls, bottle-shaped,

Plate 1. *Duportella lassa* (Spirin 7321), basidiocarp in situ.

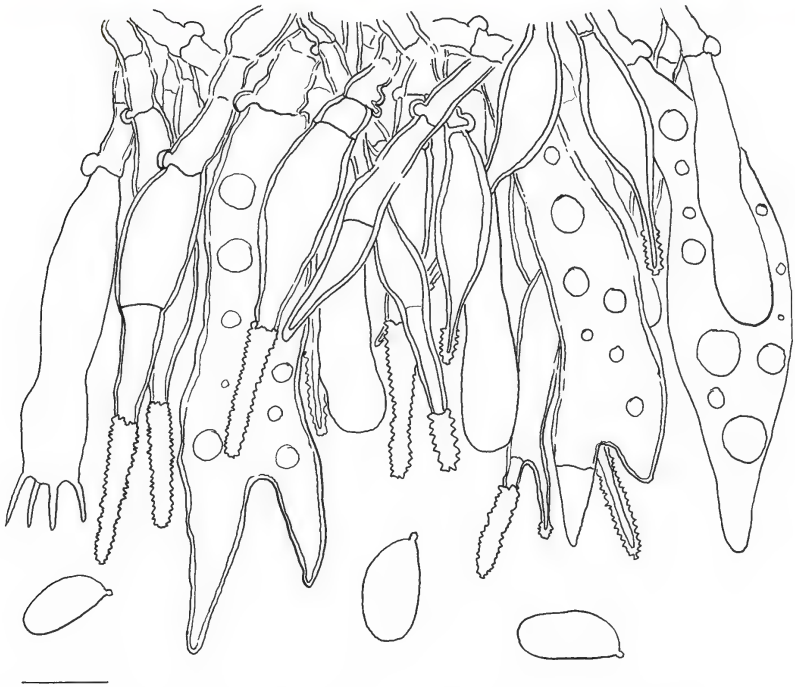

Plate 2. *Duportella lassa* (holotype), basidiocarp section. Bar = 5 μm.

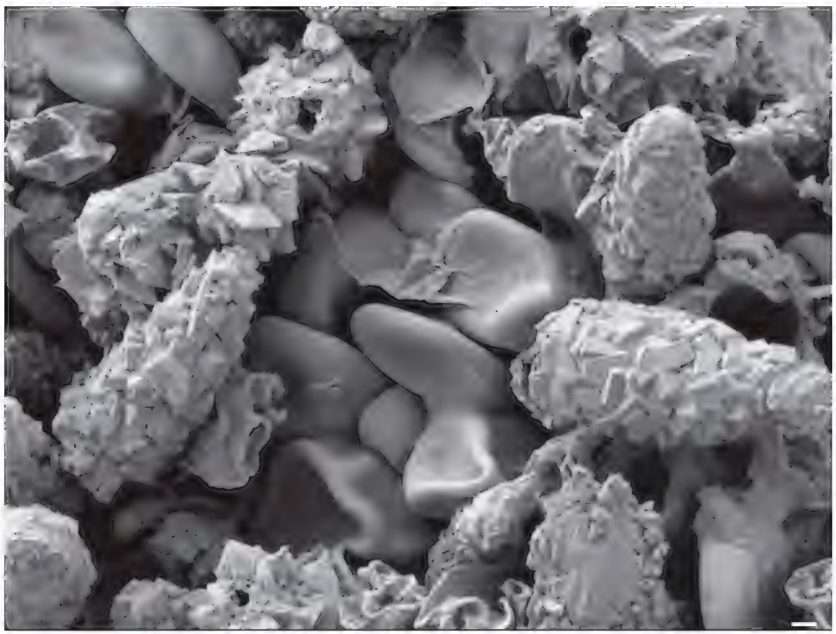

Plate 3. *Duportella lassa* (Spirin 5498), apically encrusted lamprocystidia (SEM). Bar = 1 µm.

conical or fusiform, some bifurcate, 23–50 × 6–10.5 µm; clavate, slightly thick-walled gloeocystidia common especially in senescent hymenium, 24–31.5 × 6.5–10.5 µm. Dendrohyphidia absent. Basidia suburniform, 4-spored, 17.5–26 × 5–6 µm, first hyaline and thin-walled, then basally thick-walled and brownish. Basidiospores first hyaline, later brownish (especially in older basidiocarps), smooth, thin-walled, thick cylindrical to narrowly ellipsoid or ovoid, (4.6–)4.8–6.8(–7.0) × (2.7–)2.8–4.1(–4.2) µm, L = 5.52, W = 3.32, Q' = (1.4–)1.5–2.1(–2.3), Q = 1.60–1.75 (n = 120/4), ventral side flat or slightly concave, rarely obscurely convex, inamyloid, indextrinoid, acyanophilous.

Ecology & distribution — *Duportella lassa* is so far the only boreal species known in the genus. The records derive mainly from montane old growth and secondary forests and willow thickets of East Siberia and the Russian Far East. The holotype specimen was collected from a fallen, decorticated branch of *Quercus mongolica,* but *D. lassa* occurs more commonly on dead but still attached branches of *Salix* spp.; a few records cite other angiosperm substrates (*Acer ukurunduense* Trautv. & C.A. Mey., *Duschekia fruticosa* (Rupr.) Pouzar, *Populus tremula* L., *Rhododendron dauricum* L.).

Additional specimens examined: ***Duportella lassa*** – **RUSSIA. Irkutsk Reg.: Slyudyanka Dist.**, Kultuk, on angiosperm, Sep 1902, Lönnbohm (Herb. P. Karsten 1514,

H). **Khabarovsk Reg.: Khabarovsk Dist.**, Ilga, *Salix abscondita* Laksch., 11 Aug 2012, Spirin 5173 (H), Ulika, *Populus tremula,* 13 Aug 2012, Spirin 5220 (H), Hologu, *Salix schwerinii* E.L. Wolf, 17 Aug 2012, Spirin 5340 (H, KBI), Malyi Kukachan, *S. schwerinii,* 20 Aug 2013, Spirin 5470 (H), Levyi Ulun, *Acer ukurunduense*, *Salix gracilistyla* Miq., 22 Aug 2012, Spirin 5486 (H, KBI), 5498 (H, KBI; GenBank KJ509190), *Rhododendron dauricum,* 24 Aug 2012, Spirin 5580 (H); **Solnechnyi Dist.**, Chalba, *Salix* sp., 9 Aug 2011, Spirin 4003 (H), Suluk-Makit, *Salix* sp., 19 Aug 2011, Spirin 4221 (H), Sonakh, *Quercus mongolica,* 15 Aug 2014, Spirin 7307, 7321 (H); **Verkhnebureinskii Dist.**, Dublikan Nat. Res., *Duschekia fruticosa,* 19 Aug 2014 Spirin 7570 (H), *S. schwerinii,* 23 Aug 2014, Spirin 7949 (H).

***Duportella halimi*** – **FRANCE. Loire-Atlantique**: Le Portmain, St. Marie sur mer, *Atriplex halimus* L., 31 Aug 1971, Boidin (LY-JB 6635, holotype).

***Duportella kuehneri*** – **ETHIOPIA. Shoa**: Chilomo, on branch, 10 Jan 1990, Ryvarden 28078 (H ex O).

***Duportella malenconii* subsp. *americana*** Chamuris – **USA. California**: Contra Costa, Las Trampas Creek, on *Umbellularia californica* (Hook. & Arn.) Nutt., 27 Mar 1938, Bonar (H ex UC).

***Duportella tristicula*** (Berk. & Broome) Reinking – **PAKISTAN.** Lahore, on dead branches, 27 Nov 1961, Ahmad (H ex GZM).

***Peniophora isabellina*** – **USA. Virginia**: Woodstock, *Ribes* sp., 20 Sep 1899, Shear 1191 (FH 00290618, holotype).

Comments — *Duportella lassa* belongs with the minority of monomitic species in the genus. In this group, spore shape is the key character for species identification (Andreasen & Hallenberg 2009, Boidin et al. 1991). The seemingly most similar species, *D. halima* is distinguished by its broadly ellipsoid to ovoid and larger spores [(4.8–)5.1–6.9(–7.7) × (3.7–)3.8–5.1(–5.6) µm, L = 5.86, W = 4.38, Q' = (1.1–)1.2–1.4(–1.5), Q = 1.34 (n = 30/1)] and longer basidia and cystidia (see also Duhem 1990). Moreover, *D. halimi* is known thus far only from the coastal areas of France, where it inhabits dry branches and stems of *Atriplex halimus* (Boidin & Lanquetin 1974, Duhem 1990).

The spores in *Duportella kuehneri* (Boidin & Lanq.) Hjortstam are approximately the same shape and size as in *D. lassa*, but it is a dimitic species known from central Africa (Boidin & Lanquetin 1974).

The basidiocarps of *Duportella lassa* are usually sterile; only four specimens (holotype, Karsten 1514, Spirin 5340, 5498) have numerous spores. Nonetheless, it is easily recognizable even when non-fertile due to the ochraceous to brown rimose basidiocarps, abundant dark-colored lamprocystidia, and irregularly bifurcate gloeocystidia.

*Peniophora isabellina* Burt was described as possessing some characters (basidiocarp colours, spore size, short cystidia; Burt 1925) similar to *D. lassa*. Our study of the holotype (FH) revealed a very thin, pale ochraceous basidiocarp with a smooth (not rimose) hymenial surface. Its spores, while also very scarce, are bean-shaped (with concave ventral side) and ca. 5.3–6 × 2.8–3.1 µm, and its cystidia are carrot-shaped and encrusted with a hyaline crystalline material.

In our opinion, these features preclude a close affinity between *P. isabellina* and *D. lassa*.

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# *Brachycephala exotica*, a new hyphomycete from Brazil

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Abstract —*Brachycephala exotica* gen. & sp. nov., is described and illustrated. *Brachycephala exotica* is characterized by distinct single conidiophores and monoblastic conidiogenous cells that produce solitary acrogenous 2–3-septate dark subglobose conidia with 1–3 branches that arise from the basal conidial cell to form scorpioid branched conidiophores.

Key words — asexual fungi, systematics, leaf litter, tropical fungi

## Introduction

During investigations of microfungi on dead plant material in a semi-arid region of northeast Brazil an interesting fungus was collected on decaying leaves of an unidentified plant. It showed remarkable differences from all previously described hyphomycete genera (Seifert et al. 2011) and is therefore described here as new.

## Materials & methods

Samples of submerged litter were placed in paper bags, taken to the laboratory, and treated according to Castañeda-Ruiz (2005). Mounts were prepared in PVL (polyvinyl alcohol, lactic acid, and phenol) and measurements were taken at ×1000. Micrographs were obtained with an Olympus microscope (model BX51) equipped with bright field and Nomarski interference optics. The holotype is deposited in the Herbarium of Universidade Estadual de Feira de Santana, Bahia, Brazil (HUEFS).

## Taxonomy

***Brachycephala*** J.S. Monteiro, Gusmão & R.F. Castañeda, **gen. nov.**

IF550848

Differs from *Monotosporella* by its scorpioid, branched conidiophores and rhexolytic conidial secession and from *Brachysporiella* and *Melanocephala* by its scorpioid, branched conidiophores.

Type Species: *Brachycephala exotica* J.S. Monteiro et al.

Etymology: From the Greek: *brachy-*, referring to the branched conidiophores + *-cephala*, referring to the head-shaped conidia.

Asexual fungi. Colonies on the natural substratum, hairy to funiculose, black. Mycelium superficial and immersed. Conidiophores of two types: i) distinct, single, flexuous, unbranched below, branching at the basal cell of the conidium, cylindrical, septate, smooth, brown to dark brown; ii) secondary, tertiary, quaternary, distinct, straight or slightly flexuous to somewhat curved, septate, smooth, pale brown, arising from the basal cell of each conidium, forming scorpioid branches. Conidiogenous cells monoblastic, integrated, terminal, determinate or indeterminate with several percurrent extensions, cylindrical, pale brown. Conidial secession rhexolytic. Conidia solitary, acrogenous, septate, pyriform to obovoid to globose, brown, dark brown or black, smooth, often branching at the apex of the basal cell.

***Brachycephala exotica*** J.S. Monteiro, Gusmão & R.F. Castañeda, **sp. nov.** Figs 1, 2

IF550849

Differs from *Brachysporiella*, *Monotosporella*, and *Melanocephala* spp. by scorpioid branched conidiophores originating at the basal cell of the conidium.

Type: Brazil, Ceará State, Quiixadá, Reserva Particular do Patrimônio Natural Frazenda Não Me Deixes, 4°49 S 38°58 W, on decaying leaves of an unidentified plant, 1 April 2014, coll. D.S. Alfredo & J.O. Souza (**Holotype**: HUEFS 210446).

Etymology: From the Latin: *exotica,* referring to the unusual or uncommon branched conidiophores.

Colonies on the natural substratum, hairy to funiculose, black. Mycelium superficial and immersed. Conidiophores of two types: i) distinct, single, flexuous, unbranched below, but branched at the basal cell of the conidium near its apex, 75–200 × 4–7 µm, cylindrical, inflated at the base, 4–7 septate, smooth, brown to dark brown below, pale brown toward the apex; ii) secondary, tertiary or quaternary conidiophores, distinct, straight or slightly flexuous to somewhat curved, 0–2-septate, smooth, pale brown, 15–50 × 2–4 µm, arising from the basal cell of each conidium, forming scorpioid branches. Conidiogenous

Fig. 1. *Brachycephala exotica* (holotype, HUEFS 210446). A. Conidium and conidiogenous cell. B–L. Conidia. M–O. Conidiophores, conidiogenous cells, and conidia. Scale bars: A–L = 10 µm; M–O = 20 µm.

A
B
C
D
E
F
G
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Fig. 2. *Brachycephala exotica* (holotype, HUEFS 210446). A–D. Conidia and branches formed in the basal cell. E–F. Conidia and secondary conidiophores. G–K. Conidia and secondary and tertiary conidiophores in scorpioid branches. Scale bars = 10 µm.

CELLS monoblastic, integrated, terminal, determinate or indeterminate, with several percurrent extensions, cylindrical to subulate, 10–20 × 3–6 µm, pale brown. Conidial secession rhexolytic. CONIDIA solitary, acrogenous 1–3-septate, mostly 2-septate. pyriform to obovoid to globose, 20–37 × 8–16 µm, dark brown or black at the apical cell, pale brown to brown lower cells, smooth, often with 1–3 branches arising from the upper part of the basal cell.

NOTE: The scorpioid branches arising from the basal cell of the conidia of *Brachycephala* are unique among hyphomycetes (Seifert et al. 2011) and are similar only to those of some members of the *Mucoraceae* (*Zygomycota*). *Brachycephala* superficially resembles *Acarocybellina* Subram., *Brachysporiella* Bat., and *Kramabeeja* G.V. Rao & K.A. Reddy, but in these genera the branches arise from the axis of the conidiophores (Seifert et al. 2011).

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# A new species of *Diplococcium* from the Brazilian semi-arid region

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Abstract — An undescribed hyphomycete collected during investigations of microfungi on dead plant material in a semi-arid region of northeast Brazil is described and illustrated as *Diplococcium heteroseptatum* sp. nov. The new fungus is distinguished by differentiated brown verruculose conidiophores and oblong to cylindrical 0–12-heteroseptate (but mostly 1-septate) brown conidia.

Key words— biodiversity, taxonomy, tropical microfungi

## Introduction

During a mycological survey of conidial fungi from the semi-arid region in Bahia State, Brazil, a conspicuous fungus was collected that is clearly related to the genus *Diplococcium* Grove, introduced by Grove (1885) with *D. spicatum* as the type species. The genus comprises 29 species characterized by distinct, erect or funiculose, branched, pigmented conidiophores and blastocatenate, unicellular or septate, pigmented conidia produced on polytretic conidiogenous cells (Silva et al. 2014).

## Materials & methods

Samples of bark were collected from March 2007 to November 2008 at Serra da Fumaça (10°74′S 40°36′W) and Serra da Jibóia (12°50′S 39°28′W), Bahia state. Methods for specimen collection, isolation, and morphological examination are provided in Almeida et al. (2014). Holotype and additional specimens were deposited in the Herbarium of the State University of Feira de Santana, Bahia, Brazil (HUEFS).

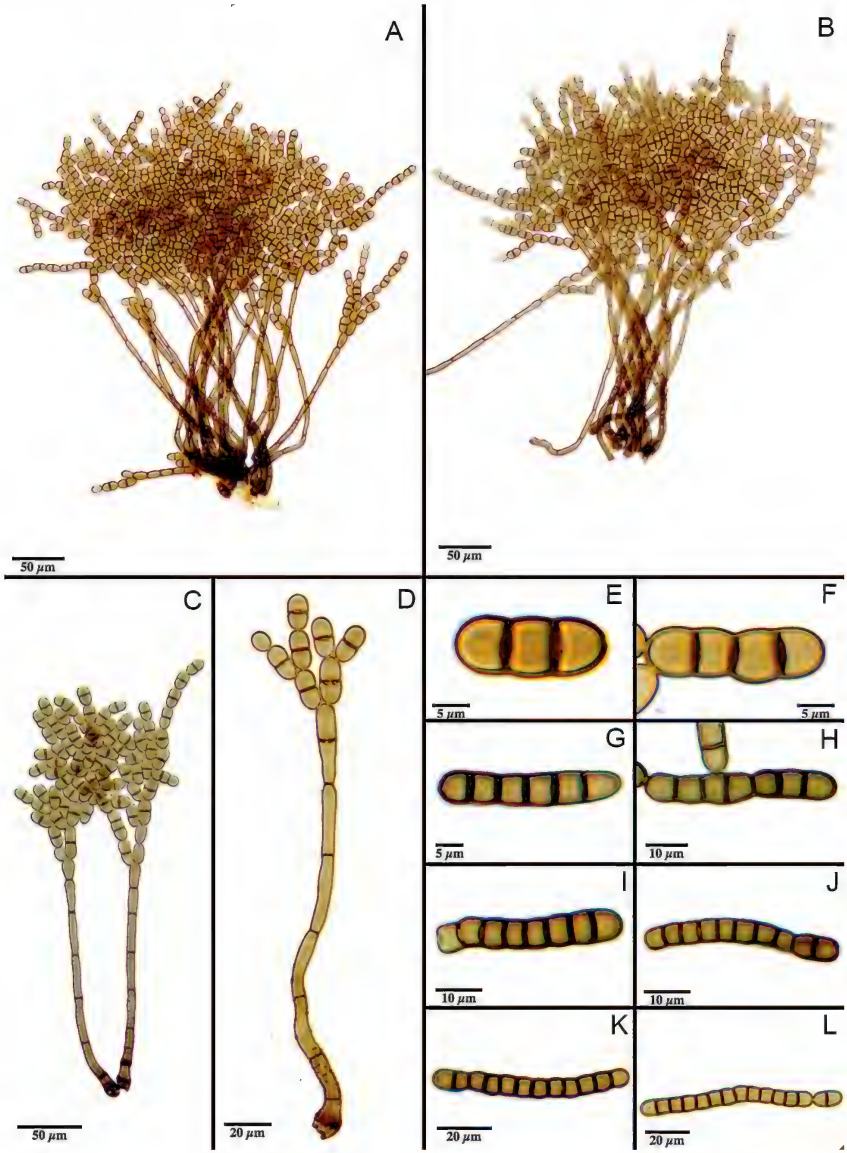


FIG. 1. *Diplococcium heteroseptatum* (holotype, HUEFS 210432): A–B. General aspect. C–D. Conidiophores, conidiogenous cells, and conidia. E–L. Conidia showing the variation in the number of septa.

## Taxonomy

***Diplococcium heteroseptatum*** D.A.C. Almeida, T.S. Santa Izabel, R.F. Castañeda & Gusmão, **sp. nov.** Figs 1, 2

MycoBank MB810699

Differs from all other *Diplococcium* spp. by the wide range of conidial septation.

Type: Brazil, Bahia State, Pindobaçu, Serra da Fumaça, on bark of an unidentified plant, 20.XI.2008, coll. D.A.C. Almeida (**Holotype**: HUEFS 210432).

Etymology: from the Greek, *hetero-*, referring to the variable numbers of septa + from the Latin, *-septatum*, referring to the septa.

Conidiophores distinct, single or grouped to profusely fasciculate, erect, unbranched or rarely branched, straight or flexuous, septate, verrucose or verruculose below, smooth toward the apex, brown, 120–300 × 4.5–9 µm. Conidiogenous cell polytretic, integrated, terminal, smooth, brown. Conidia blastocatenate, ellipsoid to oblong or cylindrical, rounded at the ends, 0–12-septate, but mostly 1-septate, constricted at the somewhat thickened septa, smooth, brown, concolorous, 10–77 × 6–10 µm.

Additional specimens examined: **BRAZIL**, **Bahia**, Serra da Jibóia, on bark of an unidentified plant, 27.III.2007, coll. T.S. Santa-Izabel (HUEFS 210428; 210429; 210430; 210430); 9.IV.2007, coll. T.S. Santa-Izabel (HUEFS 210431).

Note: *Diplococcium heteroseptatum* also differs from all other *Diplococcium* species by its profusely fasciculate, verrucose or verruculose conidiophores and the random number of conidial septa observed.

### Acknowledgments

The authors thank Dr. Prof. Bryce Kendrick and Dr. De-Wei Li for critically reviewing the manuscript. The authors thank the PPBIO Semi-arid (MCTI –CNPq/ proc. 554718/2009-0) for financial support. The first and second authors thank the (CAPES) and (CNPq) for scholarships. LFPG thanks CNPq (proc. 305413/2011-2). RFCR is also grateful to the Cuban Ministry of Agriculture and "Programa de Salud Animal y Vegetal", project P131LH003033, for facilities. We acknowledge the assistance provided by Dr. P.M. Kirk and Drs. V. Robert and A. Decock through the IndexFungorum and MycoBank websites. Dr. Lorelei Norvell's editorial and Dr. Shaun Pennycook's nomenclatural reviews are greatly appreciated.

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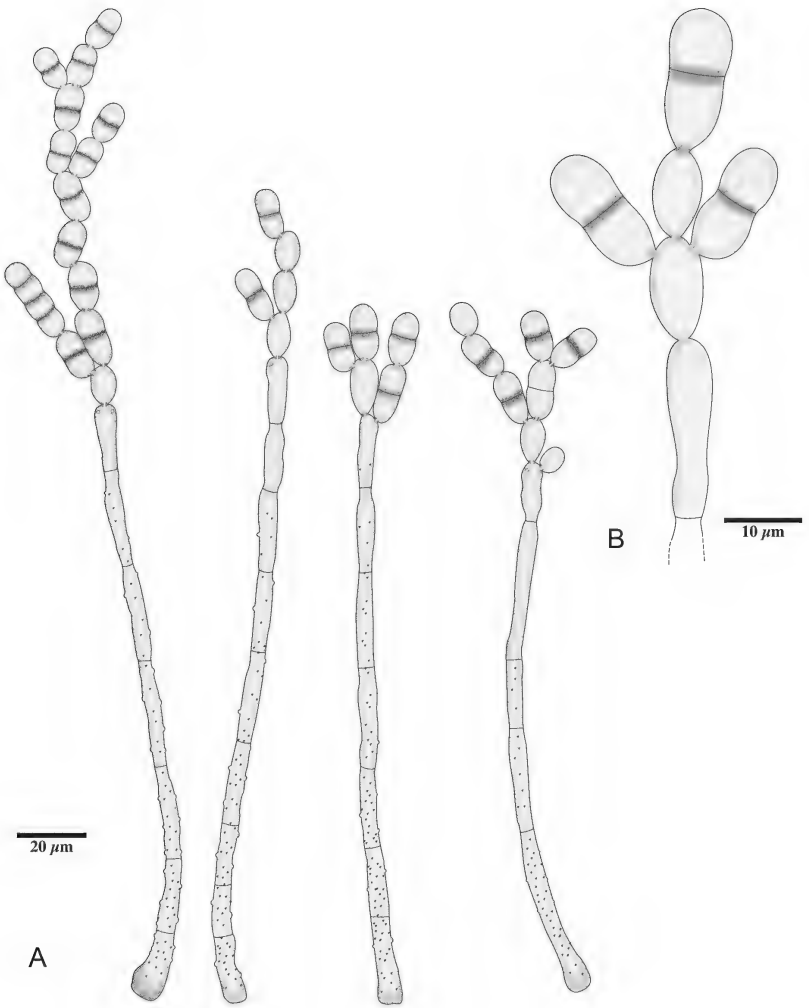


Fig. 2. *Diplococcium heteroseptatum* (holotype, HUEFS 210432):
A: Conidiophores, conidiogenous cells, and conidia. B: Conidiogenous cell and conidia.

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# *Distophragmia*, a new genus of microfungi to accommodate *Endophragmiella rigidiuscula*

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Abstract—*Distophragmia* gen. nov. is established to accommodate *Endophragmiella rigidiuscula* based on the type of conidial septa. Descriptions and illustrations are provided.

Key words— asexual fungi, systematics, tropical fungi

## Introduction

*Endophragmiella* B. Sutton (Sutton 1973) is characterized by monoblastic, integrated, terminal, indeterminate, conidiogenous cells with several or numerous enteroblastic percurrent extensions and unicellular or euseptate pigmented conidia that secede rhexolytically. *Endophragmiella rigidiuscula* shares these common characters of *Endophragmiella* species, except that its conidial septa are distosepta (Castañeda-Ruiz 1988, Leão-Ferreira et al. 2009). If species with distoseptate conidia were included in *Endophragmiella*, the generic concept would have to be expanded drastically. The distoseptate conidia provide good reason to regard *Endophragmiella rigidiuscula* as representing a separate genus. For that reason we propose *Distophragmia* as a new genus.

## Taxonomy

***Distophragmia*** R.F. Castañeda, S.M. Leão & Gusmão, **gen. nov.**

MycoBank MB810799

Differs from *Endophragmiella* by its distoseptate conidia.

Type species: *Endophragmiella rigidiuscula* R.F. Castañeda [≡ *Distophragmia rigidiuscula*]

Etymology: From the Latin *disto-* (from *distitutus*), referring to the type of septa + the Greek *-phragmia*, referring to the phragmospore.

Asexual fungi. Colonies on the natural substratum hairy, brown to black. Mycelium mostly immersed. Conidiophores distinct, single, unbranched, erect, septate, brown. Conidiogenous cells monoblastic, integrated, terminal, determinate or indeterminate, with several enteroblastic percurrent extensions. Conidial secession rhexolytic. Conidia solitary, acrogenous, ellipsoid, obovoid to globose, distoseptate, smooth, brown.

Note: *Sporidesmiella* P.M. Kirk resembles *Distophragmia*, but although *Sporidesmiella* shares conidia with a similar conidial ontogeny that are disto- and euseptate or only distoseptate, its schizolytic conidial secession is diagnostic (Kirk 1982). *Matsushimiella* R.F. Castañeda & Heredia, which superficially resembles *Distophragmia*, is separated by sympodial extensions of its conidiogenous cells and separating cells (Castañeda-Ruiz et al. 2001). In *Distophragmia,* sometimes a cupulate remnant of the detached outer layers remains on the conidiogenous cell walls after each enteroblastic percurrent extension, a character shared by *Endophragmiopsis* M.B. Ellis, *Melanocephala* S. Hughes, and *Phragmocephala* E.W. Mason & S. Hughes, genera that are distinguished from *Distophragmia* by their euseptate conidia (Seifert et al 2011).

***Distophragmia rigidiuscula*** (R.F. Castañeda) R.F. Castañeda, S.M. Leão & Gusmão, **comb. nov.** Figs 1,2

MycoBank MB810800

≡ *Endophragmiella rigidiuscula* R.F. Castañeda, Fungi Cubenses 3: 9 (1988)

Colonies on the natural substratum, hairy, black. Mycelium mostly immersed, composed of branched, septate, 2–4 µm wide, smooth, brown to dark brown hyphae. Conidiophores distinct, single, unbranched, erect, straight, cylindrical, rigid, 40–100 × 4–6 µm, 1–2-septate, smooth, 2–4 percurrent elongations, brown below, pale brown toward the apex. Conidiogenous cells monoblastic, cylindrical, integrated, terminal, determinate or indeterminate with percurrent extensions. Conidial secession rhexolytic. Conidia solitary, acrogenous, ellipsoid, obovoid to globose, 2–3-distoseptate, brown, lumina dark brown at the distosepta, 20–23 × 13–15 µm, smooth, with a cylindrical basal frill.

Specimens examined: **CUBA**, **Pinar del Rio Province**, Viñales Valley, 22°36′N 83°42′W, on decaying leaves *Byrsonima crassifolia* (L.) Kunth, 25 November 1987, coll. R.F. Castañeda-Ruiz (INIFAT C87/320, holotype). **BRAZIL. Bahia**, Santa Terezinha, Serra da Jibóia, 15°50′S 39°28′W, on decaying leaves of *Andira fraxinifolia* Benth., 5 April 2005; coll. S.M. Leão-Ferreira (HUEFS 98004).

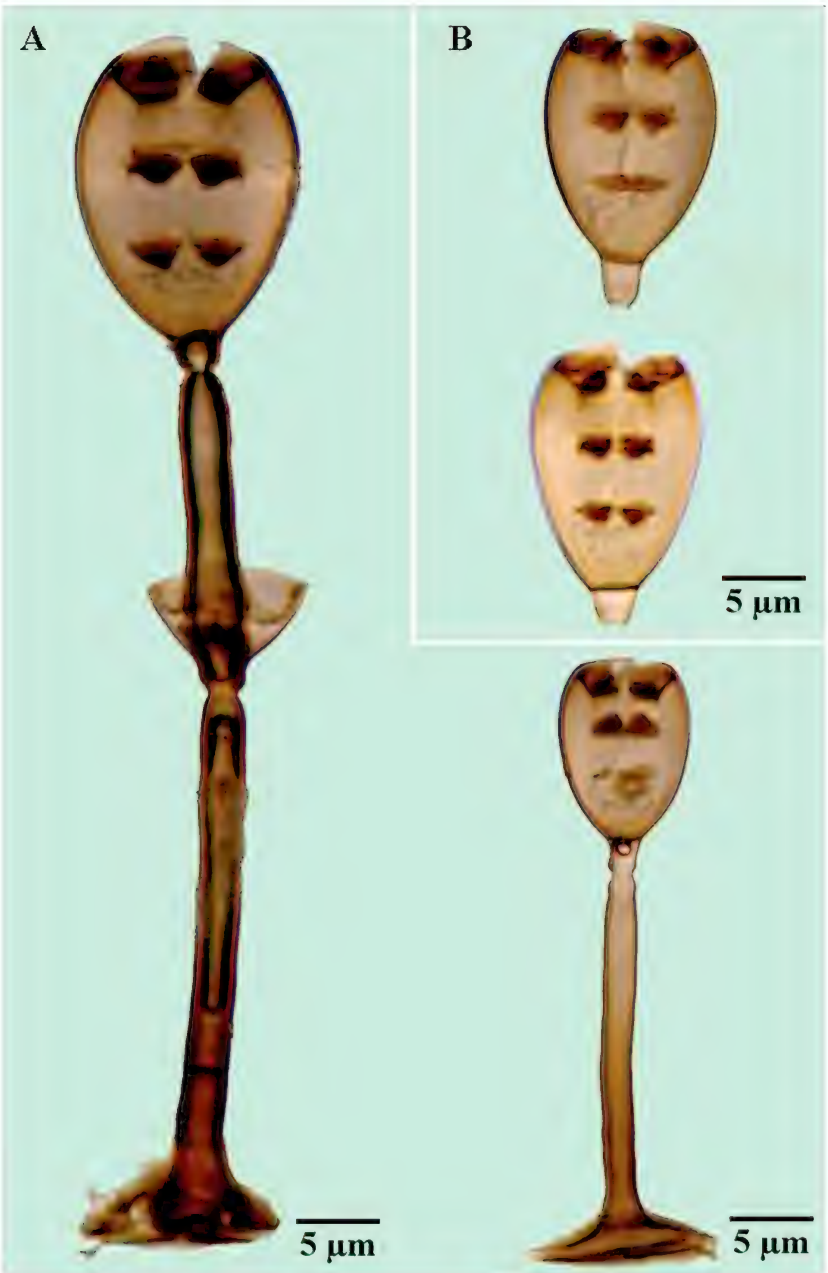


Fig. 1. *Distophragmia rigidiuscula* (HUEFS 98004).
A. Conidiophores, conidiogenous cells, and conidia. B. Conidia.

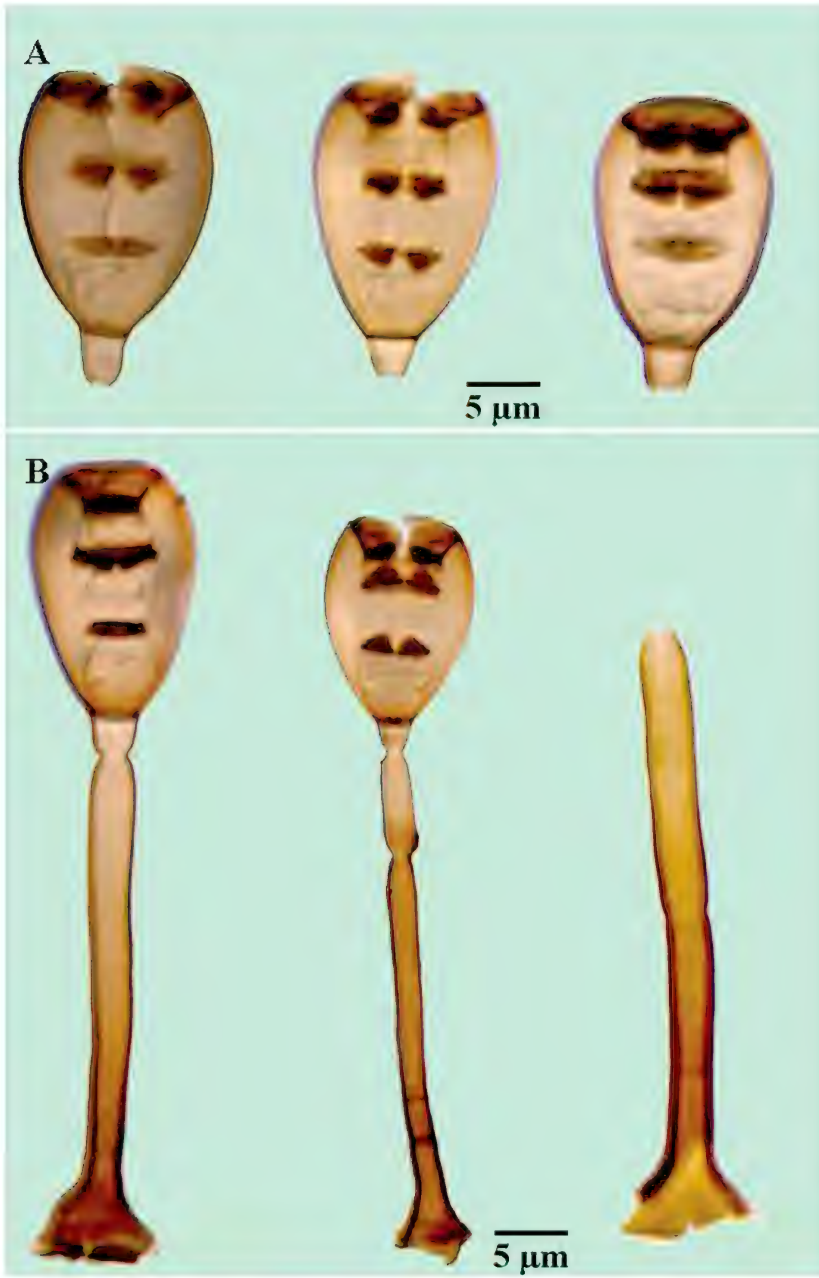


Fig. 2. *Distophragmia rigidiuscula* (HUEFS 98004).
A. Conidia. B. Conidiophores, conidiogenous cells, and conidia.

**Acknowledgments**

The authors express their sincere gratitude to Dr. De-Wei Li and Prof. Dr. Ze-Fen Yu for their critical review of the manuscript. The authors are grateful to the PPBIO Semi-arid (MCTI – CNPq/proc. 554718/2009-0) for financial support. The authors acknowledge the support provided by "Programa Ciência sem Fronteiras". RFCR is grateful to the Cuban Ministry of Agriculture and "Programa de Salud Animal y Vegetal" project P131LH003033, for facilities. We also acknowledge the assistance provided by Dr. P.M. Kirk and Drs. V. Robert and A. Decock through the IndexFungorum and MycoBank websites. Dr. Lorelei Norvell's editorial and Dr. Shaun Pennycook's nomenclatural reviews are greatly appreciated.

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# A new species of *Chaetochalara* on decaying leaves from Brazil

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Abstract —*Chaetochalara mutabilis* sp. nov., found on decaying needle-like leaves of *Araucaria angustifolia* and leaves of *Calophyllum brasiliense*, is described and illustrated. The new species is characterized by erect septate dark brown setae (most of which develop into distinct single dark brown conidiophores) and cylindrical 1-septate hyaline conidia. A key to *Chaetochalara* species is also provided.

Key words — asexual fungi, leaf litter, taxonomy, tropical fungi

## Introduction

During research on conidial fungi associated with decaying leaves of *Araucaria angustifolia* and *Calophyllum brasiliense*, an interesting fungus was collected. Its setae, conidiogenesis, and conidial features clearly suggest placement within the genus *Chaetochalara* B. Sutton & Piroz. (Nag Raj & Kendrick 1975, Taylor et al. 2001). However, the fungus shows remarkable differences from all previously described species of *Chaetochalara* and therefore is described as new.

## Materials & methods

Samples of decaying leaves of *A. angustifolia* and *C. brasiliense* were collected and placed in paper bags. In the laboratory the samples were placed in Petri dish moist chambers and stored in a polystyrene box with sterile water plus glycerol at 25°C for 30 days (Castañeda-Ruiz 2005). Mounts of slides were prepared in PVL (polyvinyl alcohol,

lactic acid, and phenol), and micrographs were obtained with an Olympus microscope BX 51. Specimens were deposited in the Herbarium of the State University of Feira de Santana, Bahia, Brazil (HUEFS).

## Taxonomy

***Chaetochalara mutabilis*** C.R. Silva, S.S. Silva, Gusmão & R.F. Castañeda, **sp. nov.** FIG. 1

MycoBank MB810746

Differs from all other *Chaetochalara* spp. by its dimorphic conidiogenous cells and its changeable setae, most of which develop into distinct unbranched multiseptate dark brown conidiophores.

TYPE: Brazil. Bahia State: Piatã, Serra da Tromba, 13°05′S 41°50′W, alt. 1263 m, on decaying leaves of *Calophyllum brasiliense* Cambess. (*Calophyllaceae*), 17.III.2014, coll. C.R. Silva (**Holotype**: HUEFS 210434).

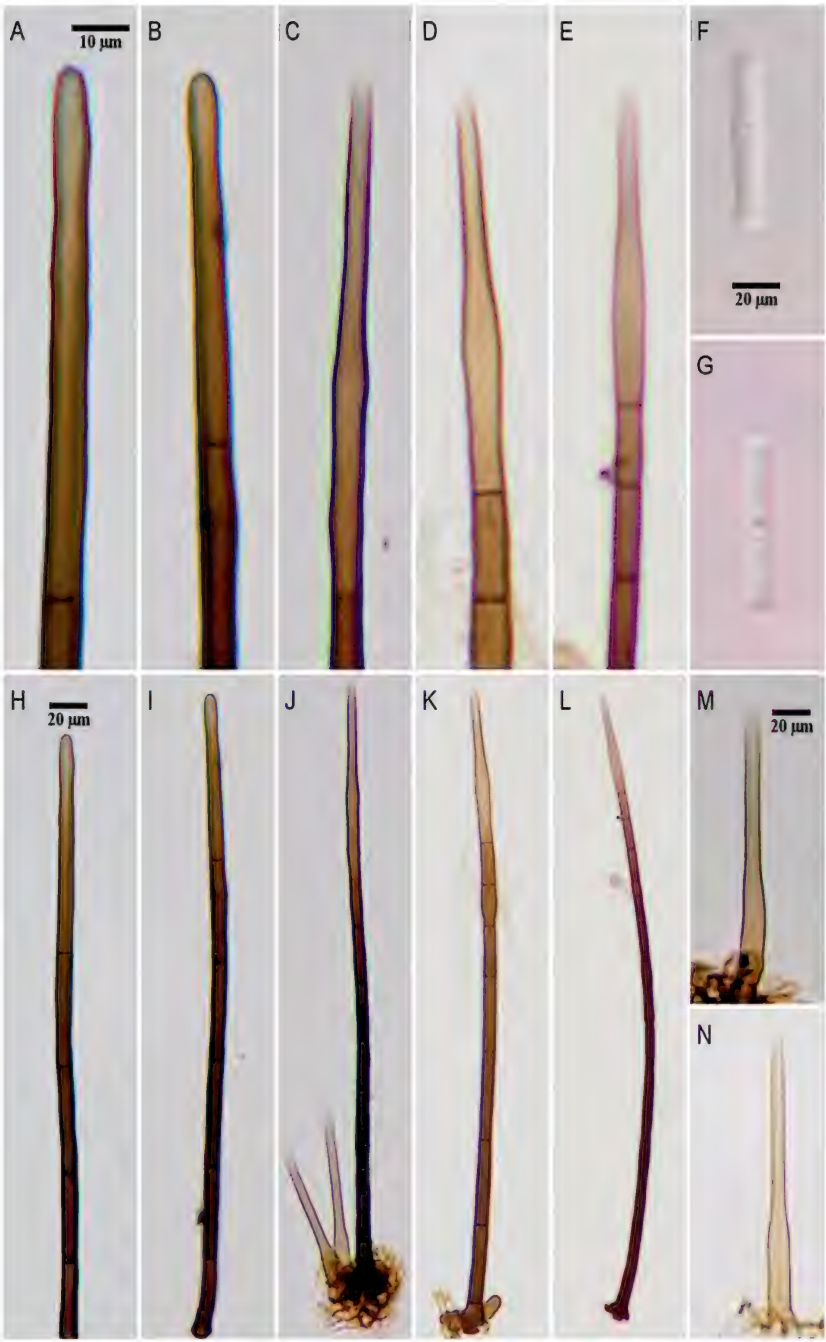
ETYMOLOGY: Latin, *mutabilis*, referring to the changeable setae, which become conidiophores.

COLONIES on the natural substrate effuse, hairy, brown. Mycelium superficial and immersed. SETAE erect, straight or slightly flexuous, cylindrical or subcylindrical, 5–14-septate, 150–345 × 4–8 µm, dark brown, pale brown toward the apex, most developing into a distinct, unbranched, dark brown conidiophore. CONIDIOPHORES distinct, single, erect, straight to slightly flexuous, unbranched, associated with the base of setae, ampulliform, pale brown, 1–3-septate, 40–82 × 4–8 µm, smooth. CONIDIOGENOUS CELLS phialidic, dimorphic: i) obclavate to subcylindrical, pale brown, 42–58 µm long; venter subcylindrical, 17–22 × 4–8 µm; collarette cylindrical 25–37 × 3 µm; gradual transition from venter to collarette; ii) ampulliform, pale brown, 24–57µm long, venter subcylindrical, 12–25 × 4–6 µm, collarette cylindrical 12–33 × 3 µm, gradual transition from venter to collarette, arising from transformed conidiophores and originating at the apical cell of the setae. CONIDIA basocatenate, cylindrical, slightly rounded at the apex and truncate at the base, 1-septate, hyaline, smooth, 10–15 × 2–2.5 µm.

ADDITIONAL SPECIMEN EXAMINED: **BRAZIL. RIO GRANDE DO SUL STATE**: São Francisco de Paula, Floresta Nacional de São Francisco de Paula 29°25′S 50°23′W, alt. 838 m, on decaying needle-like leaves of *Araucaria angustifolia* (Bertol.) Kuntze (*Araucariaceae*), 9.IX.2014; coll. S.S. Silva (HUEFS 210433).

NOTES: *Chaetochalara* was erected by Sutton & Pirozynski (1965) with the type species *C. bulbosa* B. Sutton & Piroz. The genus, which is distinguished

FIG. 1. *Chaetochalara mutabilis* (holotype, HUEFS 210434). A–B. Apex of setae. C–E. Transformed setae, originating conidiogenous cells at the apex of conidiophores (type ii). F–G. Conidia. H–I. Setae. J. General aspect of setae, conidiophores and conidiogenous cells (types i & ii). K–L. Conidiophores. M–N. Conidiogenous cells (type i). Scale bars: A-E=10 µm; F-N=20 µm.


A
10 µm
B
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G
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I
J
K
L
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20 µm
N

from *Chalara* (Corda) Rabenh. by the presence of setae, currently comprises eight species (Sutton & Pirozynski 1965, Pirozynski & Hodges 1973, Sutton & Hodges 1976, Taylor et al. 2001). *Chaetochalara ramosa* Nag Raj & W.B. Kendr. and *C. setosa* (Harkn.) Nag Raj & W.B. Kendr. resemble *C. mutabilis* in their conidial septation, but *C. ramosa* has a marginal conidial frill, *C. setosa* has an abrupt transition from venter to collarette, and both species have shorter (25–38 µm) phialides.

### Key to *Chaetochalara* species

1. Setae not developing into conidiophores ..... 2
1. Setae mostly developing into distinct cylindrical 5–14-septate conidiophores; phialides dimorphic, smooth, either ampulliform (42–58 µm long) or obclavate to subcylindrical (24–57 µm long); conidia cylindrical, 1-septate, 10–15 × 2–2.5 µm ..... *C. mutabilis*
2. All conidia unicellular ..... 3
2. All or some conidia septate ..... 4
3. Phialides narrowly ampulliform, smooth, 21–37 µm long; conidia 5–9 × 1.5–2 µm ..... *C. africana*
3. Phialides ampulliform, smooth, 21–37 µm long; conidia 6.5–10 × 1.5–2 µm ..... *C. bulbosa*
4. Conidia 0–1-septate, 10–18 × 4–5 µm; phialides subcylindrical to obclavate, 30–45 µm long, smooth ..... *C. cladii*
4. All conidia septate ..... 5
5. Phialides verruculose ..... 6
5. Phialides smooth ..... 7
6. Phialides ampulliform, 48–77 µm long; conidia 10–27 × 2.5–4 µm ..... *C. aspera*
6. Phialides subcylindrical, 70–90 µm long; conidia 9–14 × 5–7 µm ..... *C. proteae*
7. Phialides arising as branches of short conidiophores, subcylindrical, 25–38 µm long; conidia 9–14 × 3–4.5 µm ..... *C. ramosa*
7. Phialides not arising as branches of short conidiophores ..... 8
8. Phialides ampulliform, 25–38 µm long; conidia 11–15 × 1.5–2.5 µm ..... *C. setosa*
8. Phialides long lageniform, 80–100 µm long; conidia 16.5–19 × 2.5–3 µm .. *C. laevis*

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by Dr. P.M. Kirk and Drs. V. Robert and A. Decock through the IndexFungorum and MycoBank websites. Dr. Lorelei Norvell's editorial review and Dr. Shaun Pennycook's nomenclature review are greatly appreciated

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# Two new species of *Spadicoides* and *Sporidesmiella* from Yucatán, Mexico

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Abstract — *Spadicoides sylvatica* sp. nov. and *Sporidesmiella mammillata* sp. nov., both collected on decaying plant material in a Mexican dry tropical forest, are described and illustrated. *Spadicoides sylvatica* is distinguished by its ovate to obclavate, 3–4-septate, smooth, golden brown to brown conidia. *Sporidesmiella mammillata* is characterized by conidia that are solitary acrogenous, obclavate to fusiform, sub-rostrate, 4–7-distoseptate, smooth, and golden brown.

Key words — asexual fungi, systematics, tropical fungi

## Introduction

Saprobic dematiaceous hyphomycetes are highly diverse on plant material in tropical forests, where many new genera or species have recently been discovered (e.g., Castaneda Ruiz et al. 2009, 2012; Heredia et al. 2013, 2014; Zhang et al. 2009, 2011). During a mycological survey of fungi associated with decaying plant material from a Mexican dry tropical forest, two interesting fungi were collected that showed remarkable differences from all previously described *Spadicoides* and *Sporidesmiella* species. The two fungi are described here as new.

## Materials & methods

Samples of plant debris (twigs, bark, leaves, and petioles) were collected in paper bags. In the laboratory the samples were placed in Petri dish moist chambers and stored

in a 170 L polystyrene box with 200 mL sterile water plus 2 mL glycerol at 25°C for 30 days (Castañeda-Ruiz 2005). During this period, the samples were examined for the presence of conidial fungi. Slides were prepared in polyvinyl alcohol and lactic acid. Measurements were made at a magnification of ×1000. Micrographs were obtained with a Nikon eclipse 80i microscope equipped with bright field and Nomarski interference optics. The type specimens are deposited in the Herbarium of the Instituto de Ecología A. C., Xalapa, Mexico (XAL).

## Taxonomy

***Spadicoides sylvatica*** Heredia, R.F. Castañeda & R.M. Arias, **sp. nov.** Fig. 1a–c

MycoBank MB812922

Differs from *Spadicoides yunnanensis* by its ovate to obclavate, 3–4-septate, longer, and narrower conidia.

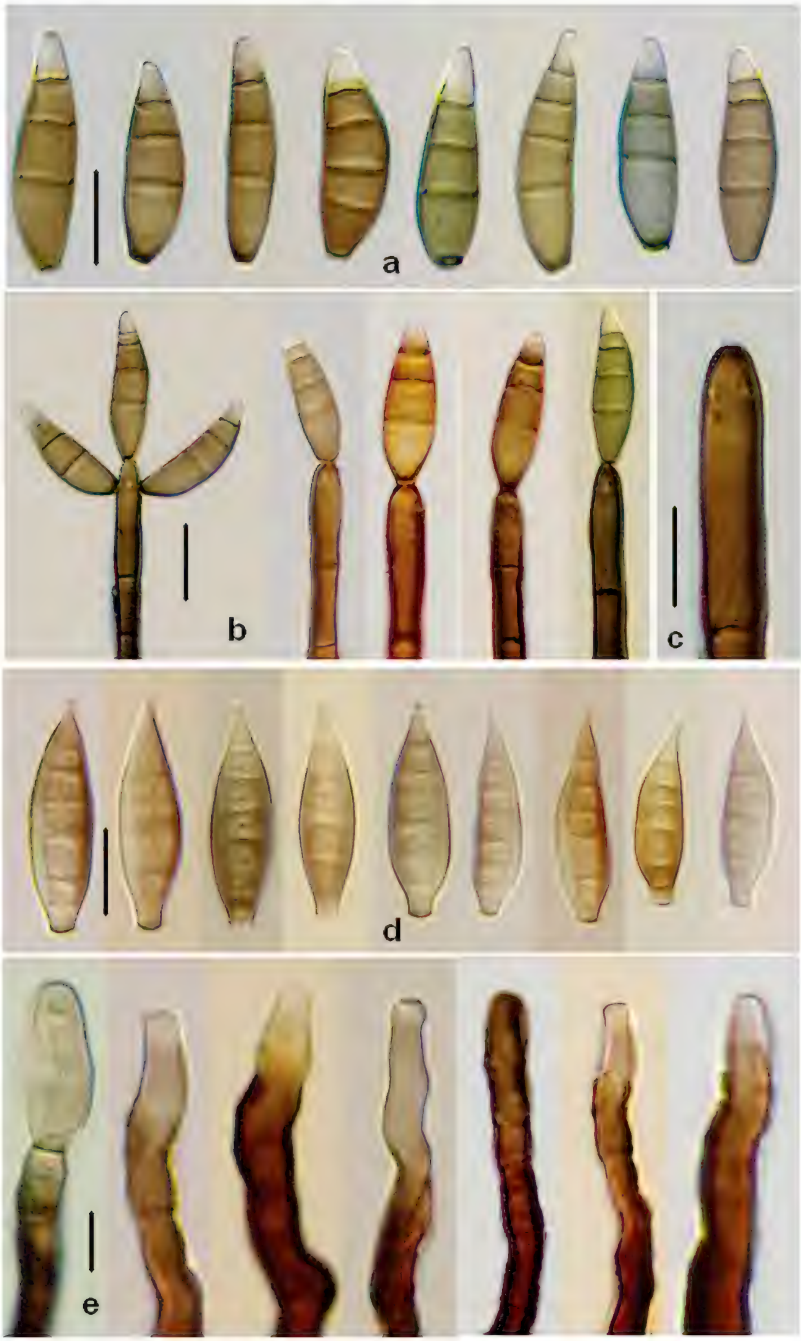
Type: Mexico, Yucatán State, Oxkutzcab municipality, Kaxil Kiuic Biocultural Reserve, 20°17′N 89°23′W, dry tropical forest, on decaying twig, 28 January 2014, coll. G. Heredia (**Holotype**: XAL CB1687).

Etymology: *sylvatica*, refers to woodland or forest.

Colonies on the natural substrate effuse, hairy, dark brown to brown. Mycelium mostly immersed, composed of septate, branched, brown, smooth hyphae. Conidiophores differentiated, mononematous, simple, erect, straight, 5–8-septate, smooth, dark brown, 180–220 × 6–9 µm. Conidiogenous cells polytretic, integrated, terminal and intercalary, cylindrical, brown, 13–28 × 5–6.5 µm. Conidia solitary, acropleurogenous, ovate to obclavate, obtuse at the apex, truncate at base, 3–4-septate, smooth, brown, apical cells very pale brown and verruculose, 22–32 × 7–8 µm.

Note: *Spadicoides* (Hughes 1958) is distinguished by differentiated erect, straight or flexuous, unbranched conidiophores with polytretic, terminal and/or intercalary conidiogenous cells that produce solitary, cylindrical, globose, obclavate to irregular, euseptate, pigmented conidia. Thus far, 36 species have been accepted in the genus (Xia et al. 2013). Only one species is similar to *S. sylvatica*, *S. yunnanensis* L.G. Ma & X.G. Zhang, which differs by its conidia, which are obpyriform to ovoid, 2–3-septate, smooth, brown, shorter, and wider (18.5–28 × 6.5–10 µm) and have rounded or acute, hyaline, smooth apical cells (Ma et al. 2010).

Fig. 1. ***Spadicoides sylvatica*** (holotype, XAL CB1687). a. Conidia. b. Conidiogenous cells and conidia. c. Conidiogenous cell. ***Sporidesmiella mammillata*** (holotype, XAL CB1686). d. Conidia. e. Conidium and conidiogenous cells. Scale bars = 10 µm.


a
b
c
d
e

***Sporidesmiella mammillata*** Heredia, R.F. Castañeda & R.M. Arias, **sp. nov.**

MycoBank MB812923 Figs 1D–E, 2D

Differs from *Sporidesmiella pseudoseptata* by its shorter conidia with 4–7 distosepta (mostly 6-distoseptate) and a mammillate apical cell.

Type: Mexico, Yucatán State, Oxkutzcab municipality, Kaxil Kiuic Biocultural Reserve, 20°17′N 89°23′W, dry tropical forest, on decaying twig, 28 January 2014, coll. G. Heredia (**Holotype**: XAL CB1686).

Etymology: Latin, *mammillata*, referring to the breast-like conidial apical cell.

Colonies on the natural substrate effuse, hairy, dark brown to black. Mycelium immersed, composed of septate, branched, brown, smooth, 1–2.5 µm diam. Conidiophores differentiated, mononematous, erect, flexuous or slightly geniculate, with 4–10-enteroblastic percurrent extensions, dark brown or black, paler at the end, smooth, 80–220 × 5–11 µm. Conidiogenous cells monoblastic, cylindrical, integrated, indeterminate, with several enteroblastic percurrent extensions, pale brown to brown. Conidial secession schizolytic. Conidia solitary, acrogenous, obclavate to fusiform, mammiform at the apex, 4–7-distoseptate (mostly 6-distoseptate), smooth, golden brown, 23–32 × 6.5–8 µm.

Note: Kirk (1982) established *Sporidesmiella* with *S. claviformis* as type; the genus is characterized by conidia that are solitary, acrogenous, mostly distoseptate (some species with a proximal basal euseptum), pale olivaceous brown or subhyaline and produced by a monoblastic, terminal, integrated, indeterminate, enteroblastic percurrent elongated conidiogenous cell. In the recent key to accepted *Sporidesmiella* species by Ma et al. (2012), of the six species that can be compared with *S. mammillata* — *S. archidendri* Jian Ma & X.G. Zhang, *S. ciliaspora* W.P. Wu, *S. fusiformis* W.P. Wu, *S. machili* Jian Ma & X.G. Zhang, *S. pseudoseptata* (M.B. Ellis) Subram., *S. verruculosa* W.P. Wu — all clearly differ (see Table 1, Fig. 2).

Table 1. Comparison of *Sporidesmiella mammillata* and similar species.

| Species | Conidial size (µm) | No. of Distosepta |
|---|---|---|
| *S. archidendri* | 100–160 × 13–17 | 19–29 |
| *S. ciliaspora* | 45–55 × 8–9 | 9–19 |
| *S. fusiformis* | 64–80 × 12–13 | 14–17 |
| *S. machili* | 57–110 ×7.5–10 | 9–15 |
| ***S. mammillata*** | **23–32 × 6.5–8** | **4–7** |
| *S. pseudoseptata* | 35–56 × 7–8 | 5–8 |
| *S. verruculosa* | 85–95 × 15–21 | 17–18 |

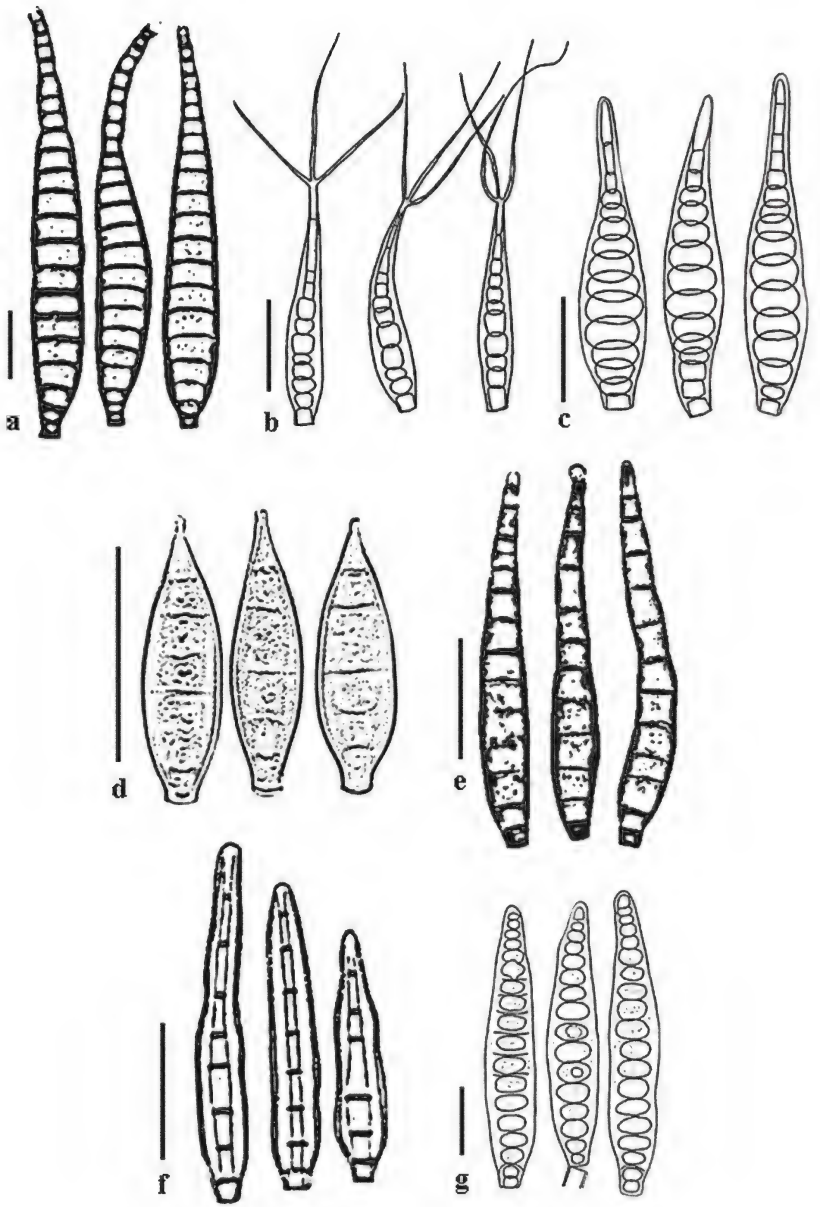



FIG. 2. *Sporidesmiella* representative conidia.
a. *S. archidendri*. b. *S. ciliaspora*. c. *S. fusiformis*. d. *S. mammillata*.
e. *S. machili*. f. *S. pseudoseptata*. g. *S. verruculosa*. Scale bars = 20 μm.

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# *Pholiota olivaceophylla*, a forgotten name for a common snowbank fungus, and notes on *Pholiota nubigena*

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Abstract — A name has been found for a common species in *Pholiota* subg. *Flammuloides* fruiting during and soon after snowmelt in the subalpine *Abies* forests of California: *Pholiota olivaceophylla* is characterized by rather pale slime-covered basidiocarps, relatively pale brown ellipsoid to slightly phaseoliform spores, 6.0–8.5 × 3.5–5.0 µm, with an inconspicuous germ pore, and abundant lageniform pleurocystidia. The ITS sequence of the type collection of *Ph. olivaceophylla* matches those of recent collections. From phylogenetic analyses and morphology, it is clear that the secotioid *Nivatogastrium nubigenum* [=*Pholiota nubigena*] is nested within *Pholiota*; this species has retained ballistospores and the typical curved sterigmata for active spore dispersal.

Key words — *Abies magnifica*, biodiversity, *Strophariaceae*

## Introduction

The genus *Pholiota* (Fr.) P. Kumm. is generally characterized by (pale) yellow to brown basidiocarps with (in most species, notably excepting the type) a viscid to gelatinous, often scaly, pileus, an annulus, rusty to dark brown smooth to slightly rough spores with a germ pore, cheilocystidia and pleurocystidia (in a number of species as chrysocystidia), and typically lignicolous habit (e.g., Jacobsson 2009). Smith & Hesler (1968), in their overview of North American species of *Pholiota,* used a rather broad genus concept but a narrow species concept and gave descriptions of 205 species for North America, 163 of which were described as new. Subsequently, several of these species were shown to be synonyms of each other or to belong to other genera that even Smith & Hesler (1968) recognized as distinct, e.g., *Agaricus* L. and *Stropharia* (Fr.) Quél.

(Jacobsson 1990, 1997; Noordeloos 1999; Norvell & Redhead 2000; Redhead 1984a,b). In modern treatments of *Pholiota* for various regions in Europe with narrower genus concepts, 24–28 species are recognized (Holec 2001, Jacobsson 2009, Noordeloos 2011, Holec & Kolařík 2014, Holec et al. 2014) [excluding, among others, *Crassisporium* Matheny et al., *Flammula*[1] (Fr.) P. Kumm., *Flammulaster* Earle, *Hemipholiota* (Singer) Bon, *Hemistropharia* Jacobsson & E. Larss., *Kuehneromyces* Singer & A.H. Sm., *Meottomyces* Vizzini, *Phaeolepiota* Maire ex Konrad & Maubl., *Phaeonematoloma* (Singer) Bon, *Phaeomarasmius* Scherff., and a number of *Tubaria* species, comprising 40–50 species]. The reasons for the discrepancy in species totals between Europe and North America are multiple; it is due partly to a strong difference in both genus and species concepts and reliance on poorly documented earlier descriptions in order to be comprehensive or partly reflects variation in fresh basidiocarp characteristics leading to multiple descriptions of species. The aspect of the basidiocarps changes dramatically due to weather – the slimy species are dry during dry weather; furthermore, in the species of *Pholiota* subg. *Flammuloides* A.H. Sm. & Hesler the pleurocystidia show considerable variation in incrustation, wall thickness, and coloration among collections of the same species (see below). As a result species recognition based on morphology alone can be challenging. Many new species described by Smith & Hesler (1968) were based on only one collection, and the authors probably underestimated the variability of the species they described.

A common snowbank species in *Pholiota* subg. *Flammuloides* (with a gelatinous pileus surface and conspicuous lageniform pleurocystidia but without chrysocystidia) was regularly found in California's Red Fir (*Abies magnifica* A. Murray bis) zone in the Sierra Nevada and Southern Cascade mountains. For a number of years the fungus was considered undescribed (Arora 1986), but a scrupulous combing of Smith & Hesler's 1968 *Pholiota* monograph turned up one possible name: *Pholiota olivaceophylla*. This species was described based on one collection, occurring 'on and near very rotten Shasta fir log, Mt. Shasta, Calif. June 1954' (Shasta fir is the vernacular name for *A. magnifica* var. *shastensis* Lemmon). Besides being collected at the right time and place, the morphology also fits our unnamed species, except for the color of the lamellae. We never found olivaceous tinges in the (young) lamellae of

[1]The name *Flammula* (Fr.) P. Kumm., published in 1871, is a later homonym of *Flammula* (Webb ex Spach) Fourr. from 1868, a genus in the *Ranunculaceae;* Donk (1962) considered the latter to be invalid, but his point of view is not followed by later authors such as Jacobsson (2012). A proposal for conservation of the fungal genus *Flammula* has been put forward by Redhead (2013).

our specimens (Plate 2). Subsequently, the microscopic features of the type of *Ph. olivaceophylla* were examined and the ITS sequences of the type and recent collections were compared. Here, based on a wide sampling from different locations within California, we present a thorough description of the species with a photograph, and we place the ITS sequences in the context of the whole genus to evaluate the taxonomic position of the species.

*Pholiota olivaceophylla* is considered a snowbank fungus as described by Cooke (1944, 1955). Snowbank fungi depend on the moisture provided by the melting snow for the development of their basidiocarps, and many are able to fruit under the snow. *Pholiota olivaceophylla* starts fruiting in this way, but continues fruiting after snow melt. The fungus long known as *Nivatogastrium nubigenum* is another example of this ecological group. The snowbank fruiting habit seems to be restricted to the western North American mountains and has not been encountered in Europe. Cripps (2009) gave an overview of the more common snowbank species; with the description of *Baeospora occidentalis* L.J. Hutchison & Kropp from Utah (Hutchison et al. 2012), the number of known snowbank fungi has already increased.

## Materials & methods

Morphology—Standard methods for describing basidiocarps were applied, using the terminology of Vellinga & Noordeloos (1999). Color annotations in the macroscopical descriptions follow Kornerup & Wanscher (1967). Microscopical observations were made from dried material rehydrated in 10% ammonia. The notation [81, 4, 3] indicates that measurements were made on 81 spores in four samples in three collections; spores were observed and measured from deposits on the stipe apex, and at least 20 spores were measured per collection in side view; also for a few collections, at least 20 spores per collection were measured in frontal view. The following abbreviations are used: L = number of lamellae, l = number of lamellulae between two lamellae, avl = average length, avw = average width, Q = quotient of length and width, and avQ = average quotient. The genus name *Pholiota* is abbreviated as *Ph.* Collections are in UC, except the type collection (in MICH). Herbarium abbreviations are according to Thiers (2015, continuously updated). [For full collection information (including Genbank accession numbers) see http://mycotaxon.com/vol/130/Siegel_Table1.pdf]

DNA extraction & sequencing—Collections for this study were made specifically during the Yosemite National Park fungus survey, and during the National Forest Service surveys in the southern Cascade Range in California. We extracted DNA using a modified Sigma Extract-N-Amp kit (Sigma Aldrich, St. Louis, MO) for dried mushrooms and Whatman™ FTA™ Plant cards (Whatman Ltd) for dried tissue embedded in the cards following manufacturer's instructions. The nrITS region was amplified with the ITS1F/ITS4 primer set using an MJ PTC-100™ thermocycler (Applied Biosystems, Foster City, CA, USA) under conditions previously described (Gardes & Bruns 1993). PCR

products were cleaned using 0.5 µL of ExoSAP IT (USB Corp, Cleveland, OH, USA) per reaction and cycled at 37°C for 45 min, followed by 80°C for 15 min. Sequencing was performed using Big Dye chemistry and an ABI PRISM 3700 Genetic Analyzer (both from Applied Biosystems, Foster City, CA, USA). Sequences were edited and contigs were assembled using Sequencher 4.7 (Gene Codes Corporation, Ann Arbor, MI, USA), and deposited in GenBank.

Alignment & phylogenetic analyses—The nrITS sequences newly produced for this paper, plus all nrITS1-5.8S-ITS2 sequences of *Pholiota*, *Flammula,* and *Nivatogastrium* species and their environmental counterparts from GenBank (as of October 2013), were aligned with the program MAFFT version 7 (Katoh et al. 2002), and visually optimized. Two sequences in GenBank, GU234152 and GU234164, were excluded as they show 92% BLAST similarity with a *Conocybe teneroides* collection (JF08598), and are not close to *Pholiota*. The aligned sequence database was analyzed by maximum likelihood method (ML) using the on-line program RAxML version 7.7.1 (Stamatakis et al. 2008); 100 rapid ML bootstraps were performed, and bootstrap values are included in the ML tree of Plate 1. *Pholiota lignicola* [≡ *Kuehneromyces lignicola* (Peck) Redhead] and *Flammula* sp. (coll. UC1861000) were chosen as outgroup taxa.

## Results

The ITS alignment consists of 131 sequences (25 newly produced and 22 from California collections) and is 801 base pairs long. The resulting maximum likelihood tree shows that *Pholiota olivaceophylla* is well supported (100%) (Plate 1; see http://mycotaxon.com/vol/130/Siegel_Plate1.pdf for a larger online version). Its closest relatives in our analyses are a collection from Scandinavia labeled *Ph. "spumosa"* and the isotype of *Ph. ferrugineolutescens* A.H. Sm. & Hesler from northern coastal California. *Pholiota olivaceophylla* belongs to a clade that corresponds with the morphologically delineated subg. *Flammuloides* to which other common Californian taxa, such as *Ph. velaglutinosa* A.H. Sm. & Hesler, *Ph. highlandensis* (Peck) Quadr. & Lunghini, and *Ph. spumosa* (Fr. : Fr.) Singer belong. *Nivatogastrium nubigenum,* which forms secotioid basidiocarps, falls in the middle of subg. *Flammuloides*, close to a collection of an agaricoid *Pholiota* from Yosemite National Park and *Pholiota* sp. FJ717493 from Canada. *Flammula* is separate from *Pholiota,* as already shown by Gulden et al. (2005), and Matheny et al. (2015) in their work on various brown-spored groups, and in more wide-ranging works on *Agaricales* as a whole (e.g., Matheny et al. 2007, Moncalvo et al. 2002). Subgenera *Pholiota* and *Flammuloides* are clearly separate as well (Plate 1).

## Discussion

The coverage of the genus *Pholiota* in terms of ITS sequences is far from complete; some groups are well represented, but as a whole there is obviously much work to be done at all taxonomic levels. The goal of our phylogenetic

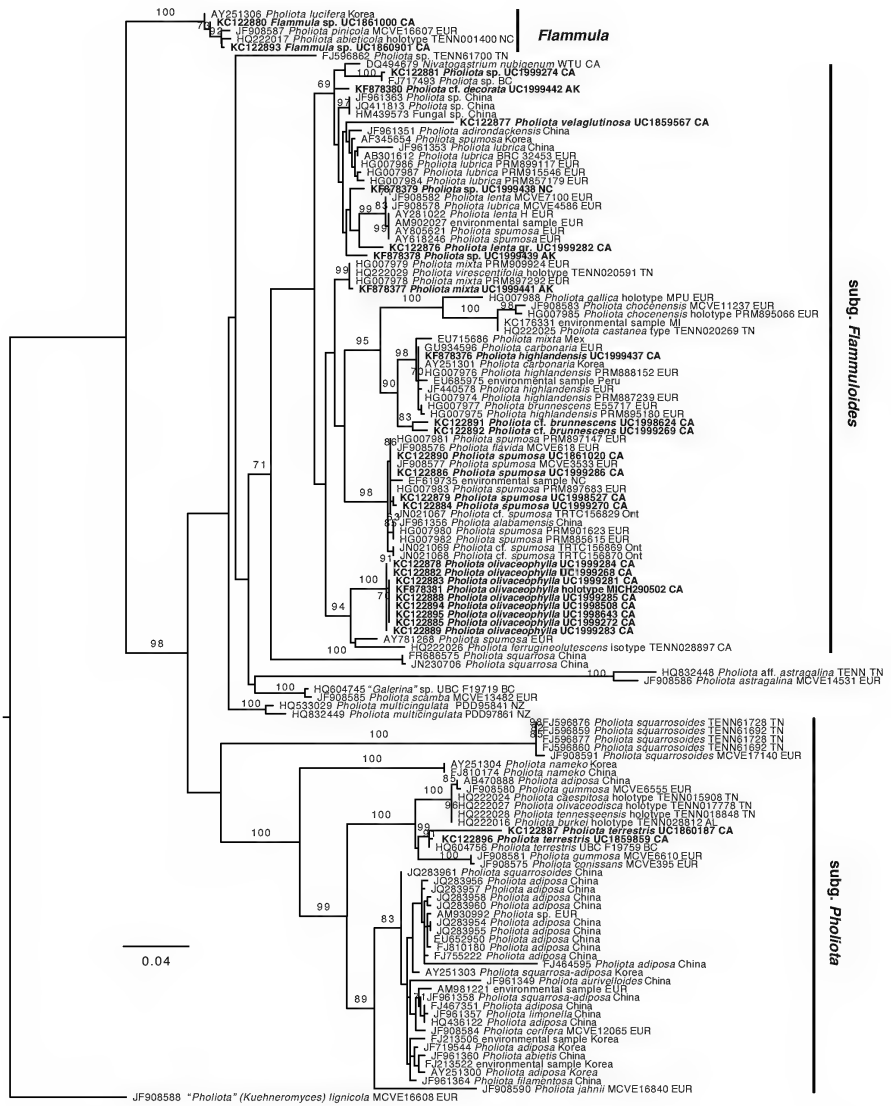


PLATE 1. ITS maximum likelihood tree of the genus *Pholiota*. Numbers on branches are ML bootstrap values >69. Each terminal leaf is annotated as: GenBank accession; Taxon name; Herbarium accession; Location. Location abbreviations: AK = Alaska, AL = Alabama, BC = British Columbia (Canada), CA = California, EUR = Europe, Mex = Mexico, MI = Michigan, NC = North Carolina, NZ = New Zealand, Ont = Ontario (Canada), TN = Tennessee. Newly produced sequences are in bold.

analysis was not to deliver a thorough hypothesis on the evolution and phylogenetic relationships of *Pholiota* taxa, but to show the grouping and position of *Ph. olivaceophylla* and *Ph. nubigena* in general terms. As is clear from Plate 1, species concepts are in need of reconsideration, as identical sequences have been produced from collections that had been identified as different species (e.g., in the *Ph. adiposa* clade), and the same name had been applied to collections that belong to different clades (e.g., *Ph. spumosa*).

Sequencing of type collections, as started by Matheny and co-workers (in TENN), should be expanded to all species described by Smith & Hesler (1968), and neotypes and epitypes should be selected and presented with their sequence data. Holec et al. (2014) also suggested increased sampling and sequencing efforts to better understand the diversity and variability of the species.

Striking is that *Pholiota castanea* A.H. Sm. & Hesler (ITS GenBank HQ222025 from the type collection), described as the only other species in stirps *Olivaceophyllae,* from the Great Smoky Mountains National Park, is not closely related to *Ph. olivaceophylla* (Plate 1), but is close to the recently described European *Ph. chocenensis* Holec & M. Kolařík. *Pholiota castanea* and *Ph. olivaceophylla* stand out among the species in subg. *Flammuloides* because of their non-gelatinized subhymenium (Smith & Hesler 1968).

Based on an analysis of a 6-locus database of the *Agaricales* as a whole, the secotioid *N. nubigenum* is a sister taxon to *Pholiota squarrosa* (Vahl : Fr.) P. Kumm., the only agaricoid *Pholiota* species included in that analysis (Matheny et al. 2007); it is a sister taxon to *Pholiota multicingulata* E. Horak in another study of the *Agaricales* based on a 4-locus database (Matheny et al. 2015). In the present ITS analysis, *Ph. nubigena* (as *Nivatogastrium nubigenum* in Plate 1) clearly nests within *Pholiota* subg. *Flammuloides*. Redhead (2014) proposed the new combination of this species in *Pholiota*.

## Taxonomy

***Pholiota olivaceophylla*** A.H. Sm. & Hesler, N. Am. Species *Pholiota*: 236. 1968.
Plates 2–6

Pileus (30–)40–80(–100) mm, convex to broadly convex, becoming applanate, occasionally wavy or lobed in age; margin inrolled when young, becoming even, undulating in age, often with veil remnants when young; surface smooth, viscid when wet, becoming tacky, often with debris stuck to it, shiny when dry, creamy-orange, pale orange-buff to pale orange-tan when young, becoming creamy-buff to tan, often with darker orange-tan streaks or patches; slime pale orange. Lamellae, L = about 50–60, l = 1–3, close to subdistant, adnate with decurrent tooth, 7–10 mm wide, pale tan to buff (5B3–5C4) when young, becoming tan, light brown to pale olive-brown, with even concolorous

PLATE 2. *Pholiota olivaceophylla* (UC1999285). Photo by Noah Siegel

edges. STIPE 50–90 × 10–18 mm, equal or enlarged at base, whitish when young, covered with pale orange-buff slimy veil except for apex, becoming off-white to dingy tan with pale orange streaks, dry and white above veil, becoming dingy tan in age, at base covered with fuzzy white mycelium that binds to organic matter, stuffed when young, becoming hollow in age. PARTIAL VEIL a mucilaginous cortina, breaking up and leaving remnants around pileus margin and a faint very pale orange ring that becomes brown with spores. CONTEXT white to pale cream in pileus, watery-white to pale tan in stipe, becoming tan to pale brown. ODOR musty, herbaceous. TASTE mild. CHEMICAL REACTIONS: 5% KOH on pileus pale yellowish orange, on upper stipe orange, little reaction on lower stipe, on pileus context bright orange, becoming orange-brown, on stipe context orangish. SPORE PRINT color medium brown.

BASIDIOSPORES in side view [200, 10, 10] 5.9–8.3 × 3.5–4.4 µm, avl × avw = 6.4–7.3 × 3.9–4.1 µm, Q = 1.45–1.95, ellipsoid to oblong, some slightly phaseoliform, in frontal view [40, 2, 2] 6.0–7.6 × 3.4–4.4 µm, avl × avw = 6.4–6.8 × 4.0–4.2 µm, Q = 1.4–1.9, avQ = 1.55–1.8, relatively thin-walled; germ pore and hilar appendage inconspicuous. BASIDIA 17–29 × 5–8 µm, 4-spored, with basal clamp connection. LAMELLA EDGE sterile. CHEILOCYSTIDIA 25–65 × 8–15 µm, with 4–6 µm wide neck, lageniform, utriform, or clavate, a few similar in shape and size to pleurocystidia, variously incrusted, with coarse material or

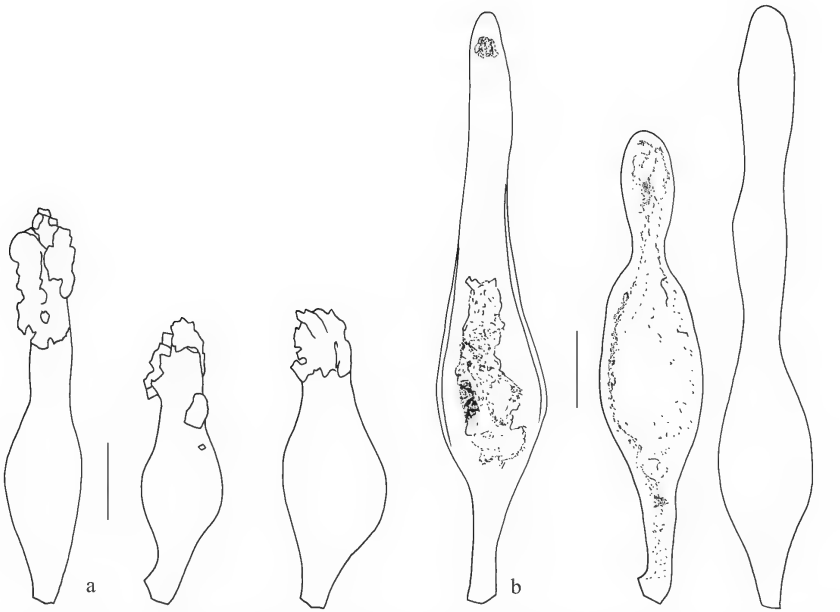


Plate 3. *Pholiota olivaceophylla*. a. Cheilocystidia; b. pleurocystidia (both from UC UC1999268). Scale bars = 10 µm. Drawing by ECV.

with some small pieces, in some collections with yellow contents in ammonia. Pleurocystidia 48–91 × 10–17.5 µm, with 4–10 µm wide neck, lageniform, very abundant, protruding from hymenium, variable in size and ornamentation, yellow in ammonia in some collections, with or without an apical covering of crystalline material, or with amorphous matter inside, or without any inclusions, with slightly thickened walls in lower part of neck. Hymenophoral trama not pigmented. Subhymenium not gelatinized. Pileipellis an ixocutis of cylindrical non-colored hyphae, 2–5 µm wide; subpellis a cutis of cylindrical to slightly inflated hyphae, 5–10 µm wide with brown walls. Stipitipellis a cutis of cylindrical colourless hyphae, 4–11 µm wide, without caulocystidia. Clamp connections present in all tissues.

Specimens examined: **USA: California, Siskiyou Co.**, Modoc National Forest, north slope of Black Mountain, near junction of Forest Road 44N33 & 44N12, in *Abies magnifica* & *A. concolor* forest, 29 May 2012, E.C. Vellinga (UC 1999279); in *A. magnifica* & *A. concolor* forest on small branches and thick duff near melting snow, 29 May 2012, N. Siegel (UC 1999281; GenBank KC122883); in *A. magnifica* & *A. concolor* forest on conifer wood, 29 May 2012, E.C. Vellinga (UC 1999285; GenBank KC122888); in *A. magnifica* & *A. concolor* forest on conifer wood & twigs, 29 May 2012, E.C. Vellinga (UC 1999276); in *A. magnifica* & *A. concolor* forest, 29 May 2012, N. Siegel (UC 1999280);

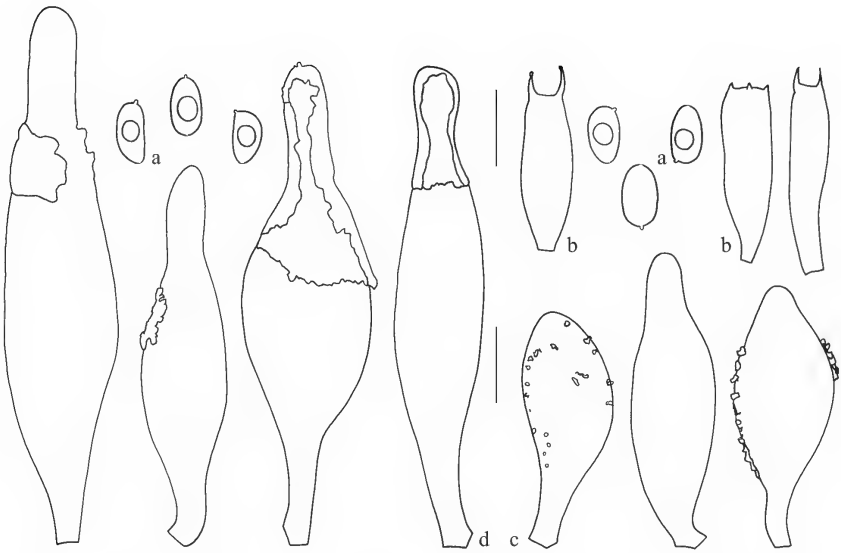


Plate 4. *Pholiota olivaceophylla*. a. Spores; b. basidia; c. cheilocystidia; d. pleurocystidia (all from UC1999272). Scale bars = 10 µm. Drawing by ECV.

Mount Shasta, on and under rotten *A. magnifica* log, 1 June 1954, W.B. Cooke (MICH 290502, holotype; GenBank KF878381); Mount Shasta, near Clear Creek Trailhead, in *A. magnifica* forest, 28 May 2012, E.C. Vellinga (UC 1999277); Trout Creek area, in *A. magnifica* and *A. concolor* forest, on conifer wood and twigs, 28 May 2012, E.C. Vellinga (UC 1999283; GenBank KC122889); Six Shooter Butte, in *A. magnifica* forest, on conifer wood, 27 May 2012, E.C. Vellinga (UC 1999278); Shasta National Forest, Trout Butte area, 28 May 2012, N. Siegel (UC 1999284; GenBank KC122878); **Tuolumne Co.**, Yosemite National Park, Crane Flat, north of gas station, in mixed coniferous forest, on conifer wood, 4 June 2010, N. Siegel (UC 1999268; GenBank KC122882); Tamarack Flat Road near Tioga Road, 37.7966°N 119.8655°W, in *A. magnifica* forest, on conifer wood, 5 June 2010, D. Viess (UC 1999272; GenBank KC122885); **Mariposa Co.**, Yosemite National Park, Glacier Point Road, 37.67333°N 119.6523°W, in mixed coniferous forest, 30 May 2010, M. Schubert (UC 1998508; GenBank KC122894); Glacier Point Road, Summit Meadow, 37.6650°N 119.6997°W, in *P. jeffreyi*, *P. lambertiana*, & *Abies* forest, on litter, 30 May 2012, N.H. Nguyen (UC 1998643; GenBank KC122895).

Habitat & distribution—Solitary, scattered, or in small groups and clusters on small buried branches, woody debris, thick duff, or well rotted logs, in *Abies concolor* (Gordon) Lindl. ex Hildebr. and *A. magnifica* forests at 1700–2200 m asl, fruiting near melting snowbanks or areas with snow cover, occasionally fruiting under snow, May–June. Widespread in the Sierra Nevada and southern Cascades in California.

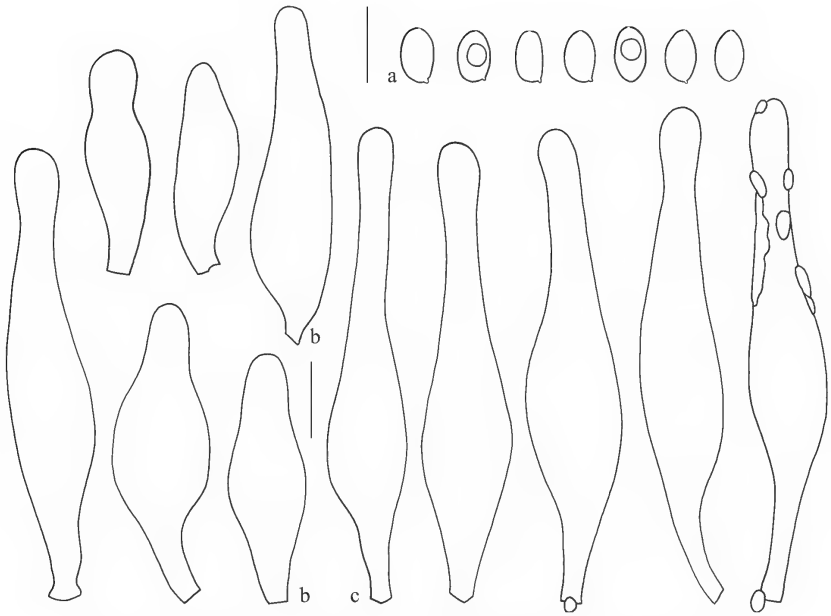


Plate 5. *Pholiota olivaceophylla.* a. Spores; b. cheilocystidia; c. pleurocystidia (all from UC1998643). Scale bars = 10 μm. Drawing by ECV.

The type collection was in good condition, and the dried specimens of recent collections look very similar. The following characters were noted for the type collection (Plate 6):

Spores [20, 1] 6.4–7.8 × 3.4–4.7 μm in side-view, avl × avw = 7.0 × 3.9 μm, Q = 1.67–1.89, avQ = 1.8, elongate, slightly phaseoliform, pale brown, with inconspicuous germ pore and hilar appendage. Basidia 20–23 × 5.0–6.5 μm, 4-spored, with basal clamp connection. Cheilocystidia present, difficult to observe, lageniform. Pleurocystidia abundant, 63-80 × 11–16 μm, lageniform, with 15–35 μm long cylindrical, rarely ventricose neck, often slightly pinched in near the wider part, with or without yellowish contents, slightly thick-walled.

Additional specimens examined:

***Flammula* sp.: USA: California, Mariposa Co.**, Yosemite National Park, White Wolf campground, 37.869383°N -119.646585°W, in *A. concolor* and *P. contorta* forest, on conifer wood, 18 Aug. 2010, P.G. Werner (UC 1860901; Genbank KC122893); Yosemite National Park, Glacier Point Road, 37.7065°N -119.5890°W, in *Pinus contorta* forest, 29 Oct. 2011, L. Rosenthal (UC 1861000; Genbank KC122880).

***Pholiota* cf. *brunnescens*: USA: California, Mariposa Co.**, Yosemite National Park, Mariposa Grove loop trail, 37.50568°N -119.60847°W, in mixed coniferous forest,

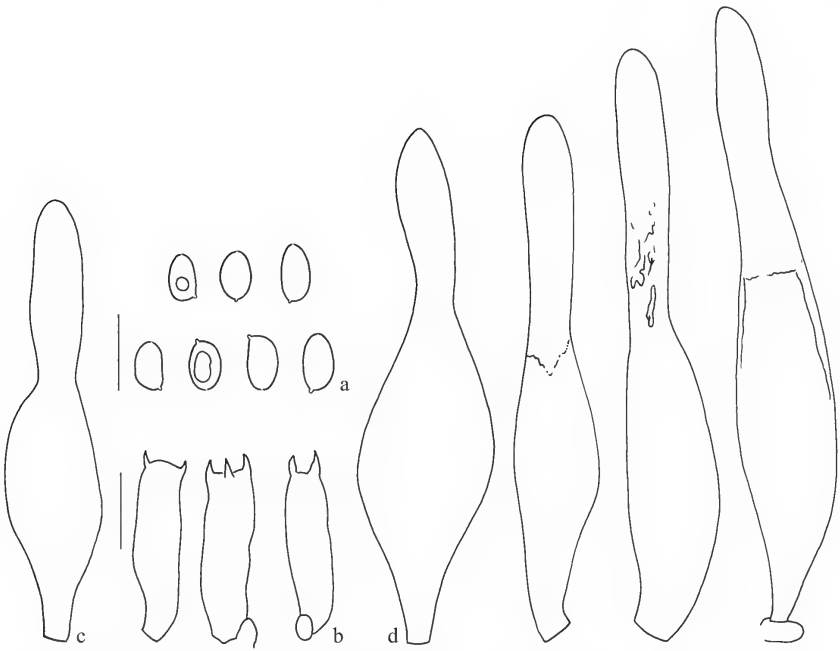


PLATE 6. *Pholiota olivaceophylla*. a. Spores; b. basidia; c. cheilocystidium; d. pleurocystidia (all from holotype). Scale bars = 10 µm. Drawing by ECV.

29 May 2010, N.H. Nguyen (UC 1998624; Genbank KC122891); **Tuolumne Co.,** Yosemite National Park, Tamarack Flat Road, 37.7966°N -119.8655°W, in *P. ponderosa*, *Pseudotsuga menziesii* & *Calocedrus decurrens* forest, N. Siegel, 5 June 2010 (UC 1999269; Genbank KC122892).

***Pholiota* cf. *decorata*: USA: ALASKA, Anchorage Co.,** Girdwood, Iditarod Trail, in forest with *Picea sitchensis* and *Tsuga,* 31 Aug. 2012, E.C. Vellinga 5567b (UC 1999442; Genbank KF878380).

***Pholiota highlandensis*: USA: CALIFORNIA, Mendocino Co.,** Mendocino, off Wheeler Street, on burnt ground under *Pinus,* 2 Jan. 2013, N. Siegel (UC 1999437; Genbank KF878376).

***Pholiota lenta* s.l.: USA: CALIFORNIA, Yuba Co.,** Bullard's Bar Recreation Area, Hornswaggle Campground, 39.4146°N -121.1205°W, mixed conifer forest, on coniferous wood, 10 Dec. 2011, E.C. Vellinga (UC 1999282; Genbank KC122876).

***Pholiota mixta*: USA: ALASKA, Kenai Peninsula,** Hope, along Palmer Creek Road, 3 Sept. 2012, E.C. Vellinga 5580b (UC 1999441; Genbank KF878377).

***Pholiota* sp.: USA: ALASKA, Kenai Peninsula,** Hope, along Palmer Creek Road, 3 Sept. 2012, E.C. Vellinga 5578b (UC 1999439; Genbank KF878378); **CALIFORNIA**, Yosemite National Park, Highway 120, in *A. magnifica* forest, on conifer wood, 30 Sept. 2011, D. Rust (UC 1999274; Genbank KC122881); **NORTH CAROLINA,** Mount Mitchell State Park, on conifer wood, 22 Sept. 2012, D. Viess (UC UC 1999438; Genbank KF878379).

***Pholiota spumosa*: USA: California, Alameda Co.,** Berkeley, along Euclid Avenue, on *Pinus* bark chips in garden, 18 March 2012, E.C. Vellinga (UC 1999286; Genbank KC122886); **Mariposa Co.**, Yosemite National Park, Wawona Meadow Loop Trail, 37.523056°N -119.636111°W, on buried conifer wood, 29 May 2010, E.P. Blanchard (UC UC 1998527; Genbank KC122879).

***Pholiota terrestris*: USA: California, Marin Co.,** Point Reyes National Seashore, Olema Trail, 37.9917°N -122.7580°W, in *Ps. menziesii* & hardwood forest, 9 Dec. 2006, K. Takeoka (UC 1859859; Genbank KC122896); Point Reyes National Seashore, Bayview Trail, 38.0608°N -122.8564°W, in *P. muricata* forest, 29 Dec. 2007, Aletheap (UC 1860187; Genbank KC122887).

***Pholiota velaglutinosa*: USA: California, Marin Co.,** Point Reyes National Seashore, Mount Vision, 38.1016°N -122.8947°W, in *P. muricata* forest, 10 Dec. 2005, Murray (UC 1859567; Genbank KC122877).

Comments—The data noted from the type collection concur with those given by Smith & Hesler (1968) and fit well the modern data for the collections from California's mountain ranges. An image of A.H. Smith's original notes can be found in Mycoportal (http://mycoportal.org).

*Pholiota olivaceophylla* commonly fruits in May and June during and just after snowmelt in the *Abies* forests of the Sierra Nevada and Cascade ranges. It can easily be distinguished from the other common species in *Pholiota* subg. *Flammuloides* fruiting at the same time in the mountains. For example, *Ph. highlandensis* and *Ph. brunnescens* A.H. Sm. & Hesler grow on recent burns, have smaller basidiocarps and deeper brown, thick-walled spores. Species in the *Ph. spumosa* complex enjoy bright yellow colors in the basidiocarps, and have brown thick-walled spores with a distinct germ pore, which are similar in size to those of *Ph. olivaceophylla*.

The European species *Ph. elegans* Jacobsson comes close in overall appearance, but differs in habitat (mainly in virgin, often deciduous, forests and fruiting in autumn), and slightly smaller, distinctly phaseoliform-amygdaloid spores, 5.0–6.7(–7.0) µm long (Holec 2001).

The North American species in *Pholiota* subg. *Flammuloides* are in serious need of revision, and interpretation of many species described by Smith and Hesler (1968) is challenging. However, some species yield to interpretation and appear to be close to *Ph. olivaceophylla* in their pale colors, but differ in critical characters: the pale species *Ph. flavopallida* A.H. Sm. & Hesler has spores 5–6 µm long, and *Ph. agglutinata* A.H. Sm. & Hesler has a white veil, and was found in late summer. There are, as far as we know, no other spring-fruiting mountain-dwelling species described. McClenaghan (1991) in her overview of northern California species gave a relatively short description of *Ph. olivaceophylla* based on one collection (which we have not studied), and stressed the olivaceous lamellae that turn to dark brown with age, characters we did not observe in the

many specimens we collected. Other characters (including the location and the time of collecting) do fit with our concept of *Ph. olivaceophylla*.

The pleurocystidia of *Ph. olivaceophylla* are highly variable in size, in contents, and in ornamentation among collections (Plates 3–6); how this is influenced by age of the basidiocarps and environmental variables is unknown. There is no overlap in pleurocystidium size among the collections with the shortest and those with the longest pleurocystidia. Constant are the relatively thin walls and relatively pale brown color of the spores under the microscope, and inconspicuous germ pore and hilar appendage. Spore color is a much better character at species level than pleurocystidium shape and size, but it is a qualitative character, and thus harder to assess.

***Pholiota nubigena*** (Harkn.) Redhead, Index Fungorum 148: 1. 2014. Plate 7

≡ *Secotium nubigenum* Harkn., Bull. California Acad. Sci. 1(4): 257. 1886.

≡ *Nivatogastrium nubigenum* (Harkn.) Singer & A.H. Sm., Brittonia 11: 224. 1959.

Comments—*Pholiota nubigena* shares both the hallmarks for subg. *Flammuloides* and the habitat with *Ph. olivaceophylla*. The pleurocystidia are

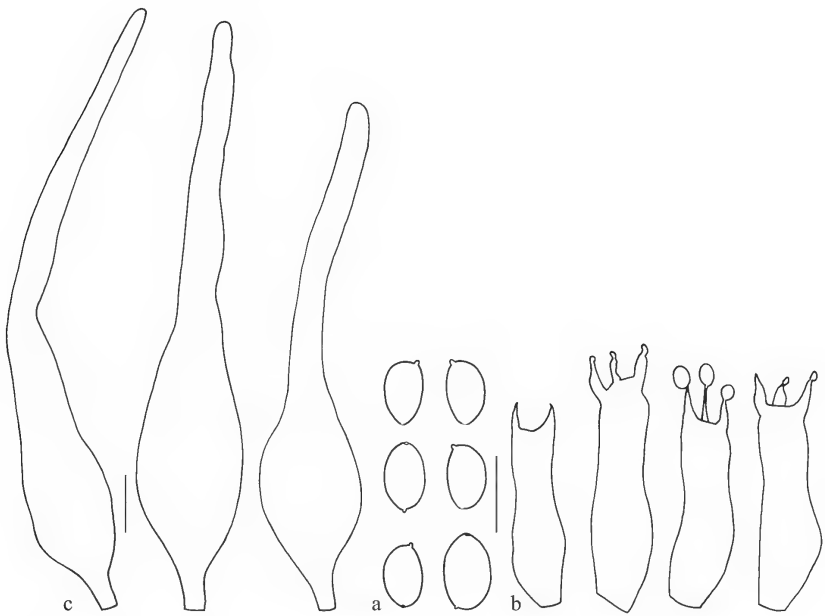


Plate 7. *Pholiota nubigena*. a. Spores; b. basidia; c. pleurocystidia (all from UC1998744). Scale bars = 10 µm (note different scale for c than in the other figs.). Drawing by ECV.

numerous and lageniform with a very long neck without yellow inclusions (chrysocystidia are absent), the spores are larger than those of *Ph. olivaceophylla* (based on our observations on collection UC 1998744 [25, 1, 1] 7.8–10.8 × 4.9–6.2 µm in side-view), with a medium brown, medium thick wall, a distinct hilar appendage, and a hardly visible germ pore (Plate 7a).

The spores are asymmetrical in side view, and the basidia have sterigmata typical for ballistospore dispersal (Plate 7b). *Pholiota nubigena* grows, like *Ph. olivaceophylla*, on conifer wood, and is widespread in the western North American mountains, with records from the southern Sierras northwards into Idaho and the Rocky Mountains in Montana (http://mycoportal.org retrieved 12 February 2015).

Specimen examined: **USA: California, Mariposa Co.**, Yosemite NP, Glacier Point Road, 37.6687°N 119.6113°W, M.G. Wood, 30 May 2010, M.G. Wood (UC 1998744).

Phylogenetically *Ph. nubigena* falls in the middle of subg. *Flammuloides*, and a relationship with *Pholiota* — which has been proposed in the past, both prior to (e.g. Singer & Smith 1959, Smith & Hesler 1968) and subsequent to molecular analyses (Matheny et al. 2007, 2015) — is again confirmed here.

**Acknowledgments**

Matthew Foltz and Patricia Rogers at MICH were so kind as to arrange the loan of the type of *Ph. olivaceophylla*. Alex Grote and Sara Zlotnik helped produce some of the DNA sequences. This work was partially funded by the Shasta-Trinity and Lassen National Forest as part of Northwest Forest Plan strategic surveys. Comments by the reviewers, Drs Scott A. Redhead and Joe F. Ammirati, and by the nomenclature editor Dr. Shaun Pennycook, on earlier versions are highly appreciated.

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# *Leucoagaricus lahorensis*, a new species of *L.* sect. *Rubrotincti*

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Abstract—*Leucoagaricus lahorensis* sp. nov. is described and illustrated based on morpho-anatomical and molecular (ITS) characteristics. The new species, which is placed in *L.* sect. *Rubrotincti*, is characterized by an umbonate to plane pileus with central obtuse orange red disc, a white to cream stipe, ascending annulus, broadly ellipsoid basidiospores, narrowly clavate to subcylindrical cheilocystidia without crystals at their apex, and straight cylindrical pileal elements.

Key words—*Agaricaceae*, macrofungi, phylogenetic analysis, Punjab

## Introduction

*Leucoagaricus* Singer (*Agaricaceae*, *Agaricales*) is represented by more than 100 species worldwide (Kirk et al. 2008, Kumar & Manimohan 2009, Liang et al. 2010, Vellinga et al. 2010, Muñoz et al. 2012 & 2013, Malysheva et al. 2013). The genus is characterized by non-striate pileus margins, free lamellae, spores that are metachromatic in cresyl blue, and the absence of clamp connections and pseudoparaphyses (Singer 1986, Vellinga 2001). *Leucoagaricus* has been shown to be polyphyletic (Vellinga 2004).

Most *Leucoagaricus* species have been described from temperate regions in North America and Europe, and little is known about the genus from tropical areas (Liang et al. 2010). Representatives of *L.* sec. *Rubrotincti* form moderately fleshy basidiomata with a context that does not change color when damaged and usually a red brown, pinkish ochre, olive, or orange pileus with radially arranged hyphae (Singer 1986). Basidiospores are characterized by a smooth surface and incomplete or absent germ pores.

Lepiotaceous fungi occur widely in Punjab at lower elevations. Previously only two *Leucoagaricus* species, *L. leucothites* (Vittad.) Wasser and *L. serenus*

(Fr.) Bon & Boiffard, have been reported from Pakistan (Ahmad et al. 1997). During macrofungal surveys conducted in the monsoon seasons of 2011–13, a species was encountered that differs macro- and microscopically from other species of *Leucoagaricus*. A detailed description and illustrations of this novel species are presented.

## Materials & methods

### Morpho-anatomical analysis

Basidiomata of *Leucoagaricus lahorensis* were carefully collected, photographed, and vouchered. The dried specimens were characterized morphologically using terminology of Vellinga & Noordeloos (2001). Colours were designated according to Munsell (1975). Basidiocarps were sectioned and placed in 5% KOH and stained with phloxine for microscopic observation. Colour reactions were also noted in Melzer's reagent. At least eighty basidiospores from two collections and twenty each of basidia, cheilocystidia, and pileal and stipe elements were measured using an ocular micrometer. The following abbreviations are used: avl = average length, avw = average width, Q = length/width of basidiospores, avQ = the mean Q of all basidiospores. Drawings of these microscopic features were made using a camera lucida attached to a compound microscope. The holotype and paratype specimens have been deposited in the Herbarium, Department of Botany, University of the Punjab, Lahore, Pakistan (LAH).

### DNA extraction, PCR amplification, & DNA sequencing

DNA was extracted by the CTAB method (Bruns 1995). The internal transcribed spacer region (ITS) was amplified using universal primers ITS4 and ITS1F (Gardes & Bruns 1993). PCR conditions were as described in Gardes & Bruns (1993). The amplified products were directly sequenced using the same pair of universal primers (Macrogen, Korea). The nucleotide sequence comparisons were performed through Basic Local Alignment Search Tool (BLAST) network services using National Centre for Biotechnology Information (NCBI), USA database. For phylogenetic analysis and sequence alignment, sequences of closely related species were retrieved from GenBank. Sequence alignment was done in Muscle Multiple sequence alignment and phylogenetic analysis was performed using Molecular Evolutionary Genetic Analysis (MEGA 5) software. Phylogenetic analyses were made by Maximum Likelihood method using Jukes Cantor Model (Tamura et al. 2011). The nucleotide sequences were submitted to GenBank.

## Results

***Leucoagaricus lahorensis*** Qasim, Amir & Nawaz, **sp. nov.** Figs 1, 2

MycoBank MB808587

Differs from *Leucoagaricus rubrotinctus* by its thin-walled larger broadly ellipsoid to amygdaloid spores and narrowly subclavate to sub-cylindrical cheilocystidia.

Type: Pakistan, Punjab, Lahore, grounds of University of the Punjab, 217 m a.s.l., gregarious on soil, 3 September 2012, A.N. Khalid T25 (Holotype, LAH 10042012; GenBank KJ701794).

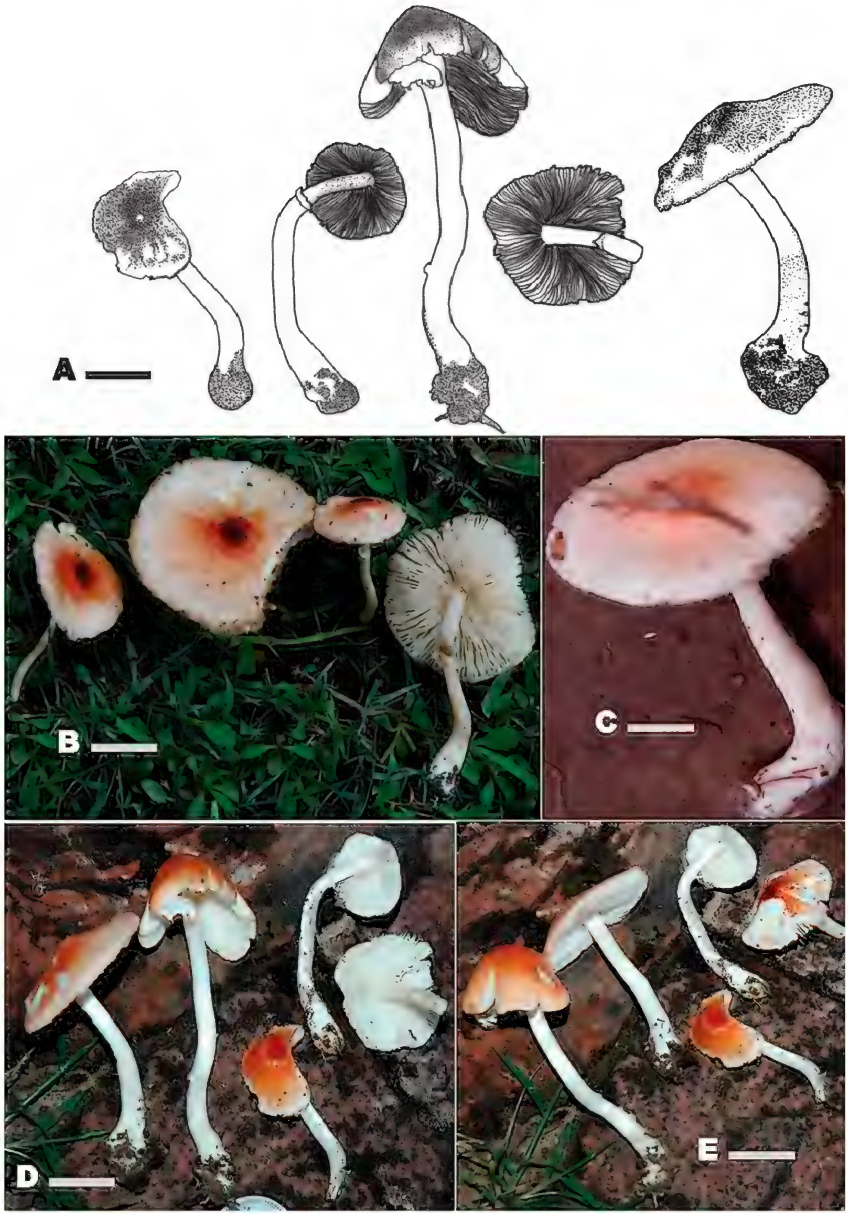


Fig. 1: *Leucoagaricus lahorensis:* basidiomata A–E (A & D–E, Holotype, B, T38; C, CM36) in their natural habitat. Scale bar: A = 13 mm, B & C = 18 mm, D–E = 20 mm.

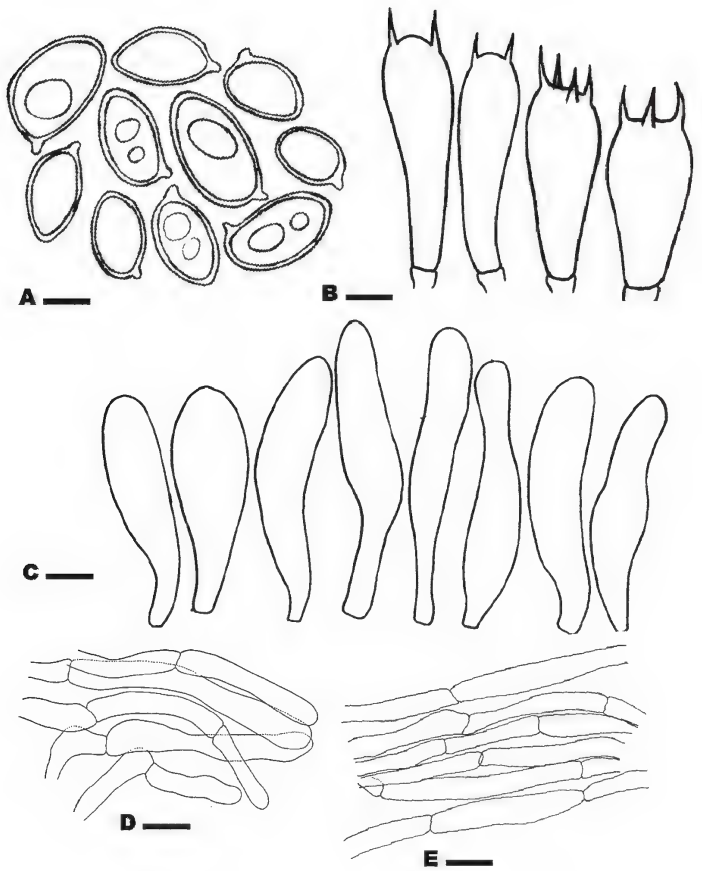


Fig. 2: *Leucoagaricus lahorensis* (Holotype):
A, basidiospores; B, basidia; C, cheilocystidia; D, stipe covering; E, pileus covering.
Scale bar: A–B = 6 μm, C = 9 μm, D = 47 μm, E = 30 μm.

Etymology: from the type locality Lahore, provincial capital of Punjab, Pakistan.

Basidiomata 3.8–7.3 cm tall. Pileus 2.5–5.5 cm in diameter, at first umbonate, then becoming plane with deflexed margins at maturity; central disc obtuse, dark reddish brown (10 R 3/10); surface squamulose, with radially arranged reddish brown fibrils, becoming sparse and light brown (7.5R5/16) towards margins over a white to cream background; context white, fleshy; margins entire, with cracks developing at maturity. Lamellae free, close, thin, membranous, white to cream (5YR9/2), edges entire; lamellulae in 3–4 tiers. Stipe 2.9–5.6 × 0.3–0.7

cm, central, equal to sub-equal, cylindrical, slightly attenuating towards pileus, with shiny white surface (5YR9/2), hollow, smooth; base slightly bulbous. Annulus present, membranous, white to cream, ascending, superior. Volva absent. Taste and odour not recorded.

Basidiospores [80/4/4], (7.3)8–10.6(10.9) × (6.1)6.4–7.6(7.8) µm, avl × avw = 8.7 × 6.7 µm, Q = 1.2–1.4, avQ = 1.3, broadly ellipsoid to ellipsoid, occasionally amygdaloid, hyaline with greenish tinge in KOH, thin-walled, smooth, apiculate, guttulate, dextrinoid in Melzer's reagent; germ pore absent. Basidia (17.2)17.5–18.9(19.1) × (10.1)10.6–11.6(11.8) µm, avl × avw = 17.8 × 11.2 µm, thin-walled, hyaline in KOH, 2–4-spored, broadly clavate to vesicular, smooth. Cheilocystidia (33.7)34.1–38.7(40) × (8)9.1–10.5(11.3) µm, avl × avw = 24.2 × 10.7 µm, hyaline in KOH, thin-walled, narrowly clavate to sub-cylindrical, smooth. Pleurocystidia not present. Stipitipellis made of cells 11.8 – 23.6 µm diam., avw = 17.6 µm, thin-walled, hyaline in KOH, parallel in arrangement, septate, unbranched; clamp connections absent. Pileipellis hyphae 5.7–11.6 µm (av = 7.5 µm) diam, light brown in colour. Clamp connections absent.

Additional material examined: **PAKISTAN, Punjab**, Lahore, University of the Punjab, 217 m a.s.l., gregarious on rich loamy soil, 18 August 2011, A.N. Khalid MCR84 (LAH 8482011; GenBank KJ701797); on grounds of botanical garden, 21 September 2012, A.N. Khalid & Tayyaba Qasim T38 (LAH 10052012; GenBank KJ701794); Changa Manga Forest, on rich soil, 28 July 2013, A.R. Niazi & Tooba Amir CM36 (LAH 2481336; GenBank KJ701795).

### Phylogenetic analysis

ITS-nrDNA amplification produced fragments of 700 -742 bp. The initial BLAST analysis revealed the maximum similarity of *L. lahorensis* with *L. rubrotinctus*. The top 100 sequences in BLAST analysis that represent *Leucoagaricus* and other related taxa were retrieved for phylogenetic analysis. From the final data set comprising 48 sequences, 47 represented the ingroup, while *Cystolepiota seminuda* (AY176350) was selected to root the tree (Fig. 3).

The final alignment comprised 763 nucleotides, of which 316 characters were conserved and 324 were parsimony informative sites. Gaps were treated as missing data. Tree topologies remained the same in all three phylogenetic analyses: Maximum Likelihood (ML), Maximum Parsimony, and Nearest Neighbour Joining).

In the ML phylogenetic tree two different *Leucoagaricus* sections were obtained: *L.* sect. *Rubrotincti* and *L.* sect. *Piloselli* (Fig. 3). The taxa that clustered together in different sections also have morphological similarities. All *L. lahorensis* sequences fall in *L.* sect. *Rubrotincti,* along with the sequences of *L. littoralis*, *L. rubrotinctus, L. sublittoralis* sensu Reid, *L. vassiljevae*, *L. wichanskyi*, and other *Leucoagaricus* species of Vellinga (2001, 2004).

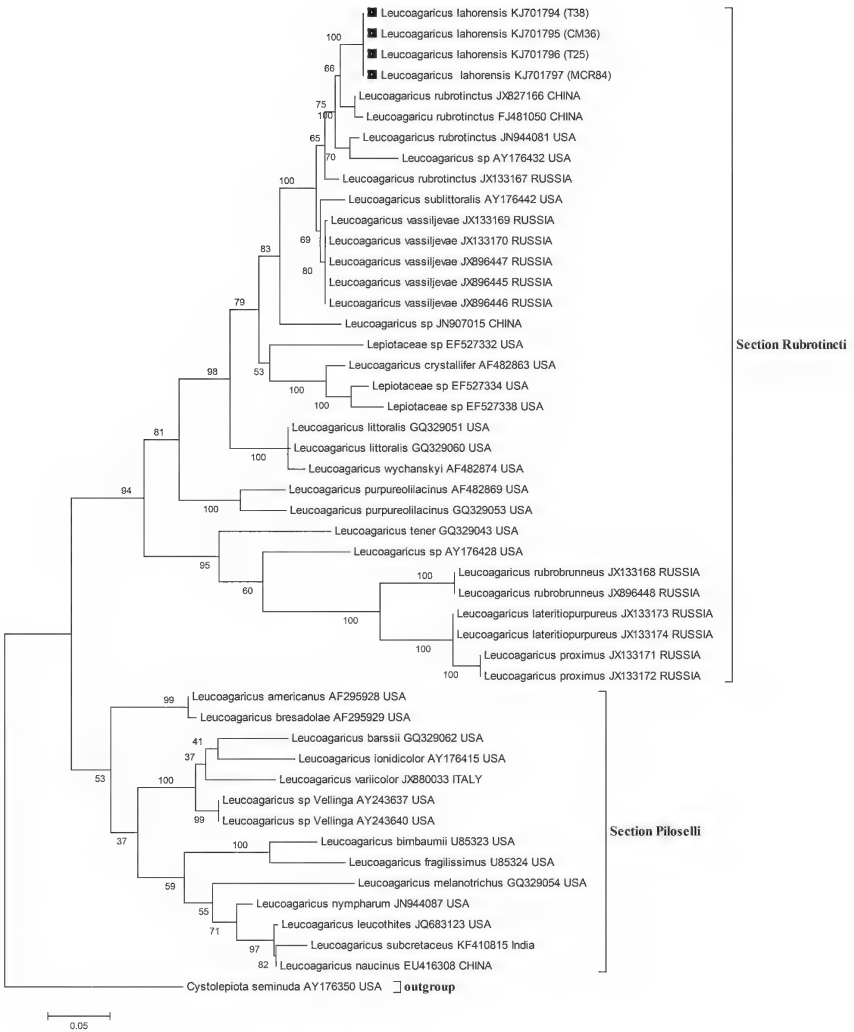


FIG. 3: Phylogram obtained from ITS region of nrDNA. The phylogenetic relationship of *Leucoagaricus lahorensis* was inferred from nrITS sequences using Maximum Likelihood method. Bootstrap values more than 50% are present above branches. *Leucoagaricus lahorensis* sequences are indicated by ■.

## Discussion

Basidiomata representing *Leucoagaricus lahorensis* were collected frequently from Lahore during the August and September rainy seasons of 2011–13. This study is based on four collections representing the new taxon: the holotype T25 and MCR84, T38, and CM36. Preliminary morphological analysis suggested that all four collections represented the same species, which our molecular analyses confirmed. The ITS-nrDNA based phylogenetic tree also supports *L. lahorensis* as separate from all other *Leucoagaricus* spp. for which ITS data are available in Genbank.

*Leucoagaricus lahorensis* is characterized by a reddish brown pileus covering with white background, radially arranged fibrils becoming sparse towards margins, close lamellae with entire margins, a white annulus, broadly ellipsoid basidiospores (occasionally with an amygdaloid apex), narrowly clavate to sub-cylindrical cheilocystidia without apical crystals, and cylindrical pileal elements with clavate to narrowly clavate terminal ends.

Our ML phylogenetic tree revealed two *Leucoagaricus* sections that agree with those recognized by Singer (1975). All species in *L.* sect. *Rubrotincti* are characterized by a reddish brown pileus covering, ellipsoid spores, tetrasporic basidia, no colour change upon bruising, and a negative ammonia reaction (Singer 1948, 1986; Bon 1993; Vellinga 2001).

All *L. lahorensis* sequences clustered together in *L.* sect. *Rubrotincti* with 72% bootstrap support. *Leucoagaricus lahorensis* forms a sister clade with Chinese collections tentatively called *L. rubrotinctus* (66% bootstrap support). The morphology of these Chinese collections is not known; *L. rubrotinctus* (Peck) Singer is an eastern North American species with an orange-red radially fibrillose pileus (Vellinga 2001). *Leucoagaricus lahorensis* is distinguished by its white annulus, broadly ellipsoid spores, and subclavate to cylindrical cheilocystidia.

Another closely related species is *L. vassiljevae* E.F. Malysheva et al. Both species share the approximately same size of pileus (4.5 cm diam for *L. vassiljevae*), red brown radially arranged fibrils on a white background, and broadly ellipsoid dextrinoid basidiospores. However, the large spores (8–13 × 5–6 μm), clavate cheilocystidia, and longer stipe (5–13 cm) of *L. vassiljevae* distinguish it from *L. lahorensis*.

*Leucoagaricus sublittoralis* (Kühner ex Hora) Singer resembles *L. lahorensis* in its pinkish brown pileus with white background, 4-spored basidia, and dextrinoid spores, but its broadly ellipsoid spores and cheilocystidia without crystals render it a different taxon. Furthermore, *L. sublittoralis* is found in clay, loamy soils (Vellinga 2001), while *L. lahorensis* is found in loamy soils.

*Leucoagaricus rufosquamulosus* T.K.A. Kumar & Manim. also shows similarities with *L. lahorensis* based on brownish red pileus covering, but the spores with germ pores set it apart from *L. lahorensis*. *Leucoagaricus glabridiscus* (Sundb.) Wuilb. has similarly long spores (10.3 µm) (Vellinga 2001) but is distinguished from *L. lahorensis* by its 1–2 tiers of lamellulae.

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# *Aspicilia volcanica*, a new saxicolous lichen from Northeast China

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Abstract — *Aspicilia volcanica* from Heilongjiang in Northeast China is described as new to science. The species is characterized by the thin grayish olive thallus, moniliform branched anastomosing paraphyses, and the presence of stictic and hypostictic acids. It grows on volcanic rock in temperate region. ITS nrDNA sequence analysis supports the taxonomic distinctness of this species.

Key words — Asia, biodiversity, *Megasporaceae*, *Pertusariales*, taxonomy

## Introduction

The lichen-forming ascomycete genus *Aspicilia* A. Massal. (*Pertusariales*, *Megasporaceae*) displays a considerable range of morphological variation (Sohrabi et al. 2011). Within the genus a number of species have radiating thalli and elongate, often ± diverging and ± branched marginal areoles, closely attached to the substratum (Nordin et al. 2011). *Aspicilia* s. lat (which in the traditional sense includes *Cicinaria*, *Lobothallia*, *Sagedia,* and *Teuvoa*) has a worldwide distribution and covers a diverse assemblage of 200–250 species (Kirk et al. 2010, Sohrabi et al. 2013). Forty-four species of *Aspicilia* s. str. (which includes *Teuvoa*) have been previously been reported from China (Wei 1991, Abbas & Wu 1998, Sohrabi et al. 2010, Li et al. 2013), but only two *Aspicilia* species (*A. subdepressa, A. transbaicalica*) were reported from Northeast China (Wei 1991, Li et al. 2013).

During a study of the lichen genus *Aspicilia* in China, some interesting specimens were collected from the Wudalianchi volcanic mountains, Heilongjiang, Northeast China. Careful morphological and anatomical

examination combined with chemical and nrITS sequence analyses has confirmed one representative, here described *Aspicilia volcanica*, as new to science.

## Materials & methods

Specimens were collected from the Wudalianchi Scenic Area, Wudalianchi City, Heilongjiang Province, China, and are preserved in Lichens Research Center in Arid Zones of Northwest China, Xinjiang University, Urumqi, Xinjiang, China (XJU). The lichen specimens were examined morphologically using a Leica Zoom 2000 dissecting microscope and anatomically with an Olympus CH compound microscope. Sections, mainly cut by hand, were studied in water. Chemical constituents were identified by thin-layer chromatography using solvent systems A, B, and C (Orange et al. 2010). Photos of the thallus and anatomical structures were taken with a Nikon Eclipse E200 stereomicroscope with Canon Digital Camera Powershot A640 and Nikon Digital Camera D50.

DNA extraction, PCR amplification, & sequencing: DNA was extracted using DNAsecure Plant DNA Kit (Tiangen, China). PCR amplification followed Martín et al. (2003) and the manufacturer's recommendations (Tiangen, China). The whole nrITS region (ITS1-5.8S-ITS2) was targeted using the primers ITS1-F (Gardes & Bruns 1993) and ITS4 (White et al. 1990). Thermocycling protocols were 95°C for 3 min linked to 35 cycles at 94°C for 30 s, 54°C for 30 s, and 72°C for 1 min, with a final extension of 72°C for 10 min. PCR products were screened on 1% agarose gels stained with ethidium bromide and sequenced by the Genewiz Inc. (Beijing).

Phylogenetic analysis & sequence comparison: We generated one ITS sequence (KM609324) and aligned it with 34 representatives (including *Lobothallia alphoplaca* as the outgroup) both by ClustalW and Muscle implemented in MEGA 6 (Tamura et al. 2013), then optimized manually. The alignment matrix of 501 nucleotide positions was submitted to TreeBase (S16691).

A phylogeny was inferred by the Maximum Likelihood method based on the Tamura-Nei model in MEGA6 and by using Bayesian inference based on GTR model with rates=Invgamma in MrBayes (Huelsenbeck & Ronquist 2011). For ML analysis, initial tree(s) for the heuristic search were obtained by applying the Neighbor-Joining method to a matrix of pairwise distances estimated using the Maximum Composite Likelihood (MCL) approach. A discrete Gamma distribution was used to model evolutionary rate differences among sites (5 categories (+G, parameter = 0.4216)).

## Results & Discussion

### ITS sequence analysis

The ITS sequence analysis supports *A. volcanica* as a separate species (Fig. 1) within the *A. cinerea*-group with close affinities to the common species, *A. cinerea* (query cover 100%, 93% identity and 2% gap). *Aspicilia volcanica* is also close to *A. laevata* (query cover 91%, 90% identity, 1% gap) and *A. indissimilis* (query cover 92%, 90% identity, 1% gap).

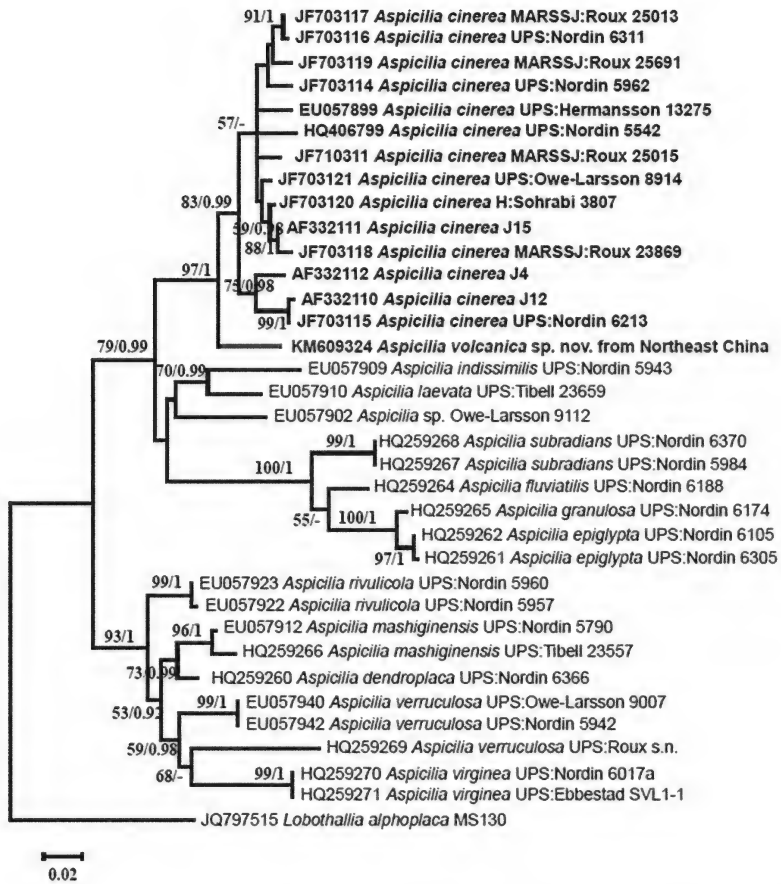


FIGURE 1. Position of the new species in the ITS phylogenetic tree of *Aspicilia* with *Lobothallia alphoplaca* as outgroup. ML bootstrap support / Bayesian posterior probabilities are shown at nodes; nodes with ML support <50 and PP <0.90 are collapsed. Branch lengths refer to the number of substitutions per site. Herbarium acronyms (where available) and specimen numbers, and isolate numbers are attached to the sequences downloaded from GenBank.

## Taxonomy

### *Aspicilia volcanica* Ismayil, A. Abbas & S.Y. Guo, **sp. nov.** FIGURE 2

FUNGAL NAME FN 570144

Differs from *Aspicilia cinerea* by its thin grayish olive thallus, the presence of stictic and hypostictic acids, and the absence of norstictic acid.

TYPE: China. Heilongjiang: Wudalianchi scenic area, 48°39.321′N 126°09.311′E, alt. 280 m, 15 July 2011, Gulbostan Ismayil & A. Abbas 20111154 (**Holotype**, HMAS-L; **isotype**, XJU; GenBank KM609324).

Etymology: The specific epithet *volcanica* refers to the substrate of the type specimen. There are 14 volcanic mounts in Wudalianchi, Heilongjiang, Northeast China.

Thallus grayish olive to olive, areolate to rimose, thin; margin flat, elongated, branching and diverging, thin, creamy white or whiter than thallus. Areoles irregular to angular and slightly verrucose, flat to ± convex, somewhat ± dispersed; separated by cracks and uneven, 0.2–0.5 mm wide and up to 1.2 mm long. Cortex paraplectenchymatous, 26–39 µm thick, uppermost part greenish black, without crystals, K–, covered with an epinecral layer, 5–10 µm thick. Medulla lax and K–. Hypothallus white or whiter than thallus, smooth at margins. Photobiont chlorococcoid, cells ± round, 8–18 µm in diam.

Apothecia aspicilioid, usually rather common, 1–2 per areole, irregular and sometimes round or angular, 0.3–0.7 mm in diam. disc black, concave, epruinose. Thalline margin flat to elevated in older apothecia, concolorous with or whiter than thallus, 0.1–0.2 mm thick. Epihymenium blackish or deep green, without crystals, K+ pale. Hymenium hyaline, 98–143 µm tall, I+ greenish blue to cupper red, K–. Hypothecium pale, 52–65 µm thick, K–, I+ persistently ink blue. Paraphyses moniliform (uppermost part distinctly moniliform), upper cells globose, branched and anastomosing. Asci *Aspicilia*-type, clavate, 8-spored, 57–104 × 16–31 µm. Ascospores hyaline, simple, ellipsoid, (13–)16–23(–26) × (10–)13–16 µm, with oil drops. Pycnidia not found.

Spot tests —K+ greenish yellow, KC–, C–, I–, PD–, UV–.

Secondary metabolites —Hypostictic acid, connorstictic acid, stictic acid (TLC).

Ecology —*Aspicilia volcanica* grows on black rock from volcanic mountain. Associated species include *Rhizocarpon* sp., *Rhizoplaca* sp. At present, it is only known from the volcanic mountain region in Northeast China at 280–400 m elevations.

Additional specimen examined — **China. Heilongjiang:** Wudalianchi, Wudalianchi Scenic Area, 48°43.213′N 126°27.220′E, alt. 400 m, 13 Jul. 2011, Gulbostan Ismayil & A. Abbas 20111143 (XJU).

Comments — When first collected in the field, *A. volcanica* was regarded as representing the common *A. cinerea* (type species of the genus), which differs by its gray to almost white thallus with quite large, sometimes confluent apothecia, a brown to olive-brown epihymenium, slightly shorter ascospores (usually <20 µm long), pycnidia and conidia present, and the presence of norstictic acid (Owe-Larsson et al. 2007). *Aspicilia volcanica* is further distinguished by its smaller somewhat ± dispersed areolae, cortex without crystals, smaller apothecia, and larger ascospores.

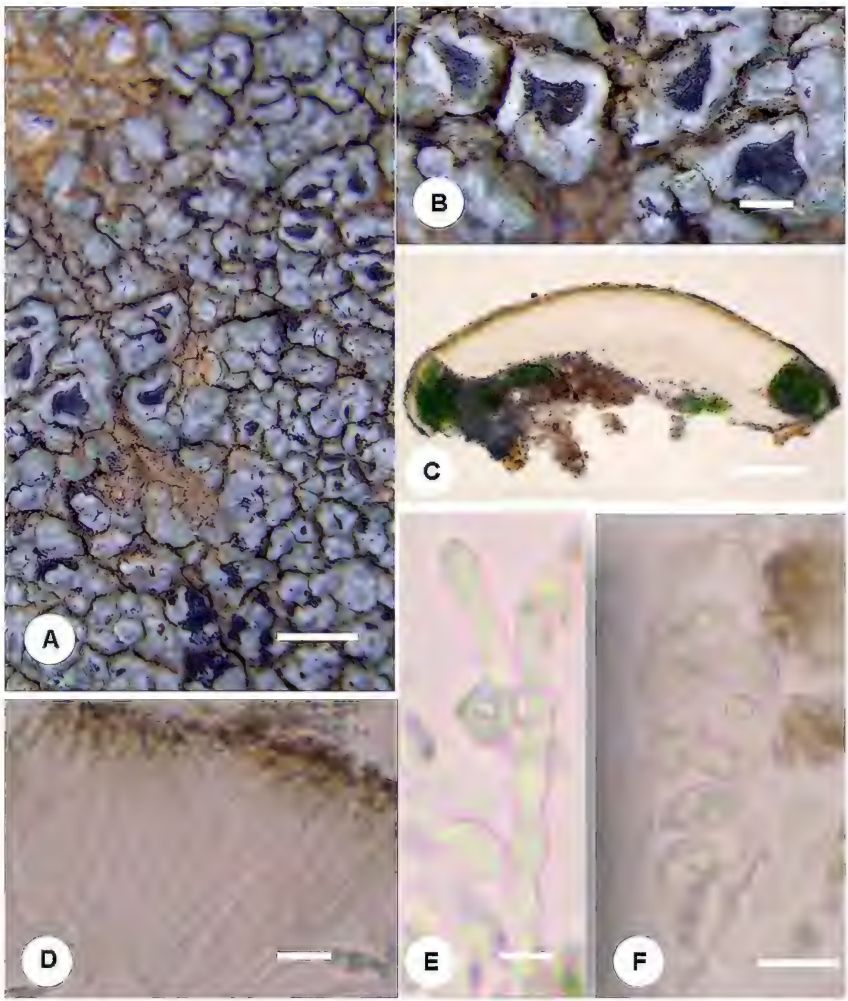


FIGURE 2. *Aspicilia volcanica* (holotype). A: general habit; B: Apothecia; C: Section of Apothecium; D: Anastomosing paraphyses; E: Moniliform paraphysis; F: Asci and ascospores. Scale bars: A = 3 mm; B = 1 mm; C = 200 µm; D = 25 µm; E = 10 µm; F = 20 µm.

Previous studies that have used DNA sequence data for species recognition in lichens required both diagnostic morphological differences and genetic distance in single-locus nrITS sequence (e.g., Nordin et al. 2011, Han et al. 2013). Our morphological and molecular data for *A. volcanica* match these criteria.

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# Redescription of *Mycorrhaphium pusillum*, a poorly known hydnoid fungus

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Abstract — The hydnoid basidiomycete *Mycorrhaphium pusillum* was found in Finland. There are only a few records of the species globally, and the genus *Mycorrhaphium* has not been recorded previously in northern Europe. Here we report a detailed description of the macro- and microscopy of this poorly known species and publish the first photographs of it, accompanied with detailed microscopic drawings.

Key words —*Mycoleptodonoides*, *Steccherinaceae*, wood pasture

## Introduction

During our extensive fungal surveys on Finnish wooded pastures we found a hydnoid basidiomycete species, *Mycorrhaphium pusillum* (Maas Geesteranus 1962), from one site in southern boreal vegetation zone. There are no previous records of the genus *Mycorrhaphium* in northern Europe. On three occasions (August 2012; August 2013; August 2014), a single sporocarp was observed growing in the very same location. Every time we conducted a very thorough survey of the surroundings, yielding no additional sporocarps in 2012 and 2013 but finding one additional sporocarp some meters from the original location in 2014. Here we report our findings. First we describe the growth site to increase the knowledge of the habitat requirements of this rare fungus. Then we describe the species in more detail than in the original description and discuss its systematic position.

FIGURE 1. *Mycorrhaphium pusillum*. Growth site in Luhanka, Finland. Photograph by Kaisa Tervonen.

## Site description

The site is a nutrient rich herb-rich forest dominated by broadleaf tree species (FIG. 1); *Betula* spp. predominate, but *Alnus incana* (L.) Moench, *Salix caprea* L., *Pinus sylvestris* L., *Picea abies* (L.) H. Karst., *Sorbus aucuparia* L., and *Rhamnus frangula* L. are also present. The site is influenced by calcareous soil. For example the presence of *Russula aurea* Pers. as well as the abundance of *Craterellus sinuosus* (Fr.) Fr. and the orchid *Listera ovata* (L.) R. Br. indicates high soil lime content (Nitare 2000, Mossberg & Stenberg 2005). The site was slash-and-burn cultivated in the late 19$^{th}$ century and then utilized as a wood pasture for cattle, probably until the 1970s when it was abandoned; most recently the area is protected as a habitat of an endangered bird species, white-backed woodpecker (*Dendrocopos leucotos* Bechstein). The site hosts especially rich community of rare fungi, including some wood-inhabiting polypores (Halme 2008; Markkanen & Halme 2012) as well as ectomycorrhizal and litter decaying agarics (Tervonen & Halme, unpublished).

Within a ten meter radius of the growth site the most frequent vascular plant species were *Pteridium aquilinum* (L.) Kuhn, *Calamagrostis arundinacea* (L.) Roth, *Hepatica nobilis* Schreb., *Alnus incana*, *Rubus saxatilis* L., *Vaccinium myrtillus* L., *Geranium sylvaticum* L., and *Cirsium helenioides* (L.) Hill. The

most frequent agaric species producing fruit bodies in the same patch were *Lactarius glyciosmus* (Fr.) Fr., *Cortinarius casimiri* (Velen.) Huijsman, a species of *Cortinarius* sect. *Anomali* Bidaud et al., *Laccaria laccata* (Scop.) Cooke, *Inocybe geophylla* (Bull.) P. Kumm., *Psathyrella senex* (Peck) A.H. Sm., *Galerina triscopa* (Fr.) Kühner, *Mycena flavoalba* (Fr.) Quél., *Mycena galericulata* (Scop.) Gray, and *Mycena pura* (Pers.) P. Kumm.

## Methods

Microscopic measurements were made using Olympus and Leica light microscopes with up to 1600× magnification. Microscopic techniques follow Miettinen et al. (2012b). Measurements are based on Finnish specimens of *M. pusillum*. Voucher specimens are deposited in the Botanical Museum, University of Helsinki, Finland (H) and the Herbarium, University of Jyväskylä, Finland (JYV).

## Species description

***Mycorrhaphium pusillum*** (Brot.) Maas Geest., Persoonia 2: 398. 1962. Figs 2, 3

Basidiocarps annual, stipitate, leathery, solitary or fusing together (2–3 caps on common stem). Caps 12–19 mm in diam., evenly rounded and applanate to

Figure 2. *Mycorrhaphium pusillum* (JYV, Tervonen 3113). Sporocarp: A. from below, illustrating the spines and stipe; B. from above, illustrating the cap surface. Photographs by Kaisa Tervonen.

asymmetric-flabelliform, pale cream-colored to pale ochraceous, sometimes with pale brownish zones; margin sharp, even, fertile. Stem 15–21 mm long and 1–3 mm thick, central or excentric, pale cream. Spines acute, slender, sometimes fusing together, 0.8–1.2 mm long, 7–8 per mm, tough, pale cream to pale ochraceous. No distinct smell.

Hyphal structure dimitic in spines, monomitic in context; hyphae hyaline, faintly cyanophilous.

Context. Hyphae relatively loosely arranged, with thickened walls, simple-septate, with clavate terminal portions forming a layer on pileal surface ("trichoderm"), 3.2–4.8 µm in diam., some inflated up to 7 µm in diam. (n = 10/1).

Spines. Tramal skeletal hyphae distinctly thick-walled to subsolid (with capillary lumen), parallel and densely arranged, some with adventive septa, (3.1–)3.7–4.9(–5.0) µm in diam. (n = 20/1); tramal generative hyphae with distinct walls, clampless, 2.5–3.5 µm in diam. Subhymenium distinct (10–15 µm thick), consisting of thin-walled, short-celled, clampless generative hyphae 2–3 µm in diam. Gloeocystidia rare, clavate, of subhymenial origin, embedded in basidial layer, 10.1–11.3 × 4.3–5.4 µm. Hyphal pegs infrequent, 10–15 × 15–20 µm, consisting of short-celled clampless hyphae 4.1–5.7 µm in diam. Basidia clavate, 1–2(–4)-sterigmatic, clampless, 9–14 × 3–4 µm.

Basidiospores thin-walled, thick cylindrical, with more or less flattened ventral side, tapering to the apiculus, (2.7–)2.9–3.6(–3.8) × (1.8–)1.9–2.2(–2.3) µm, L = 3.03, W = 2.00, Q' = (1.3–)1.5–1.7(–1.7), Q = 1.52 (n = 60/2), usually with a prominent oil-drop, inamyloid, acyanophilous.

Habitat—In herb-rich forest dominated by *Betula* spp., on mossy, knotty mull ground. No certain connection with wood was detected.

Specimens examined: **FINLAND. Etelä-Häme**: Luhanka, Kuruvuori, on ground, 18.VIII.2012, Mustola 1618 & Toivonen (H); 30.VIII.2013, Tervonen 3113 & Sundström (JYV, H). **ITALY. Piedmont**: Turin, Cantalupa, on wood of *Fagus sylvatica*, 11.III.1984, Bernicchia 2400 (H).

## Discussion

*Mycorrhaphium* Maas Geest. is now accepted as a small genus comprising both stipitate and sessile hydnoid fungi, and it was shown to be a member of the *Steccherinaceae* (Miettinen et al. 2012a). According to some sources (www.indexfungorum.org), *Mycorrhaphium* is regarded as a synonym of *Mycoleptodonoides* Nikol., typified with *M. vassiljevae* Nikol. (Nikolaeva 1952), an East Asian species with a monomitic hyphal structure and allantoid basidiospores. The author VS studied the holotype of *M. vassiljevae* (Herb. LE) as well as some additional collections from the Russian Far East. *Mycoleptodonoides vassiljevae* is a monomitic species having wide, clamped hyphae (in contrast to

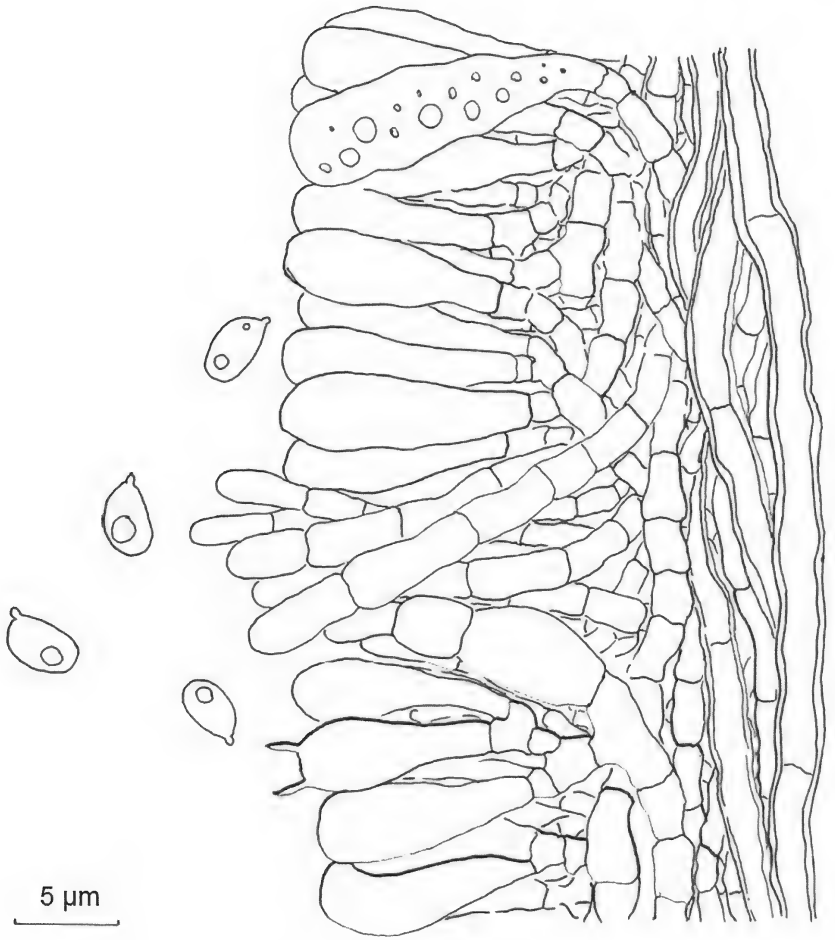


FIGURE 3. *Mycorrhaphium pusillum* (H, Mustola 1618).
Skeletal and generative hyphae, basidia, gloeocystidia, and basidiospores.
Drawing by Viacheslav Spirin.
[The characters match the second collection (Tervonen 3113) from the same site.]

clearly dimitic basidiocarps of the *Mycorrhaphium* species); in addition, it has neither the gloeocystidia nor hyphal pegs characteristic of all *Mycorrhaphium* species studied by us (including the generic type, *M. adustum* (Schwein.) Maas Geest.). Thus we accept the opinion of Maas Geesteranus (1961, 1962) that *Mycoleptodonoides* and *Mycorrhaphium* are two independent, seemingly not closely related genera. Here we follow the generic concepts proposed by

him and consider all dimitic species (including *M. pusillum*) as members of *Mycorrhaphium*. The taxonomic position of *Mycoleptodonoides,* which is still unclear, will be clarified in further DNA-based studies.

*Mycorrhaphium pusillum* is quite small, but easily recognizable and visible and probably not readily confused with any other species. Still, our record is the only one in the whole of northern Europe, and *M. pusillum* has been found only a few times in central and southern Europe. The site where we recorded the species is regionally quite unique regarding the stand quality and species assembly, suggesting that *Mycorrhaphium pusillum* may be very demanding in its environmental requirements. Consequently, we believe that this species is truly rare instead of just being overlooked.

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# *Micropsalliota pseudoglobocystis*, a new species from China

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Abstract — *Micropsalliota pseudoglobocystis* sp. nov. from China is introduced. The species is described and illustrated, and its phylogenetic placement is determined using molecular data. The new species is compared with the most similar taxa in the genus. This is the first report of the genus *Micropsalliota* from China.

Key words — *Agaricaceae*, taxonomy, phylogeny

## Introduction

*Micropsalliota* Höhn. (*Agaricaceae*) was established by Höhnel (1914) and later emended by Pegler & Rayner (1969) and Heinemann (1976). *Micropsalliota* species are often encountered at the sides of forest trails in tropical areas (Zhao et al. 2010). *Micropsalliota* is similar to *Agaricus* L. as both genera have an annulus on the stipe, free gill attachment, and brown basidiospores. Phylogenetic analyses of ITS and LSU sequence data have established that *Micropsalliota* is monophyletic (Zhao et al. 2010). *Micropsalliota* can be distinguished from other similar genera with dark spore prints by its small to medium sized fruiting bodies, ellipsoid to cymbiform basidiospores with an apical thickening in the endosporium, often capitate or subcapitate cheilocystidia, and pileipellis hyphae encrusted with a pigment that turns olive to green in $NH_4OH$ (Zhao et al. 2010).

Heinemann (1980, 1983, 1988, 1989), Heinemann & Little Flower (1983), and Heinemann & Leelavathy (1991) described about 40 species from the tropics of Africa, America, India, Indonesia, and Malaysia. Zhao et al. (2010) have since added eleven new taxa to this genus from northern Thailand. There are presently no reports of *Micropsalliota* species from China.

A survey of *Agaricaceae* has been carried out in southwestern China since 2012. Morphological and molecular studies have revealed some undescribed species, one of which is formally introduced in this paper as *Micropsalliota pseudoglobocystis*.

## Materials & methods

### Morphological examination

Specimens were collected from Tongbiguan National Natural Reserve located at Yingjiang County, Yunnan Province, China, on 19 July 2013. Photographs were taken in the field and specimens were wrapped in aluminum foil and kept separately in a box in order to avoid mixing or crushing. Macromorphological features were described and macrochemical reactions were made from fresh samples as soon as possible after returning from the field. Specimens were dried overnight in a food drier, sealed in plastic bags, and deposited in the herbarium of Southwest Forestry College, Kunming, China (SWFC) and Herbarium Mycologicum Academiae Sinicae, Beijing, China (HMAS).

Anatomical features (including the pileipellis, partial veil, basidiospores, basidia, and cystidia) were recorded from dry specimens following the protocols of Largent (1986). Dimensions were calculated from at least 20 measurements of anatomical features (spores, basidia and cystidia) and abbreviated as $x$ = mean length by width ± SD; Q = quotient of basidiospore length and width; and $Q_m$ = mean of Q-values ± SD.

### Molecular experiment and phylogenetic analysis

DNA was extracted from the dried specimens using the E.Z.N.A. Forensic DNA Extraction Kit (D3591-01, Omega Bio-Tek). ITS regions and 5.8S rDNA were amplified using primers ITS4 and ITS5 according to Zhao et al. (2010) with some modifications. PCR products were sent to Shuoyang Biotechnology Company for sequencing.

Newly produced sequence and sequences downloaded from GenBank were aligned using BioEdit v. 7.1.3.0 (http://www.mbio.ncsu.edu/bioedit/bioedit.html) and ClustalX 2.0 in default setting (Thomson et al. 1997). The alignments have been submitted to TreeBASE (submission ID 16500).

Maximum Parsimony (unweighted) analysis were performed using PAUP*4.0b10 (Swofford 2004). One thousand heuristic searches were conducted with random sequence addition, with tree bisection-reconnection (TBR) branch swapping and gaps treated as missing data. Parsimony bootstrap values were obtained from 1000 bootstrap replicates, with starting trees obtained via stepwise addition, random sequence addition, TBR branch swapping, and Max-trees set to 1,000,000.

MrModeltest 2.2 was used to determine the appropriate model of nucleotide substitution for this data for Maximum likelihood analysis and Bayesian inference (Nylander 2004). Maximum likelihood (ML) analysis was performed in PAUP*4.0b10

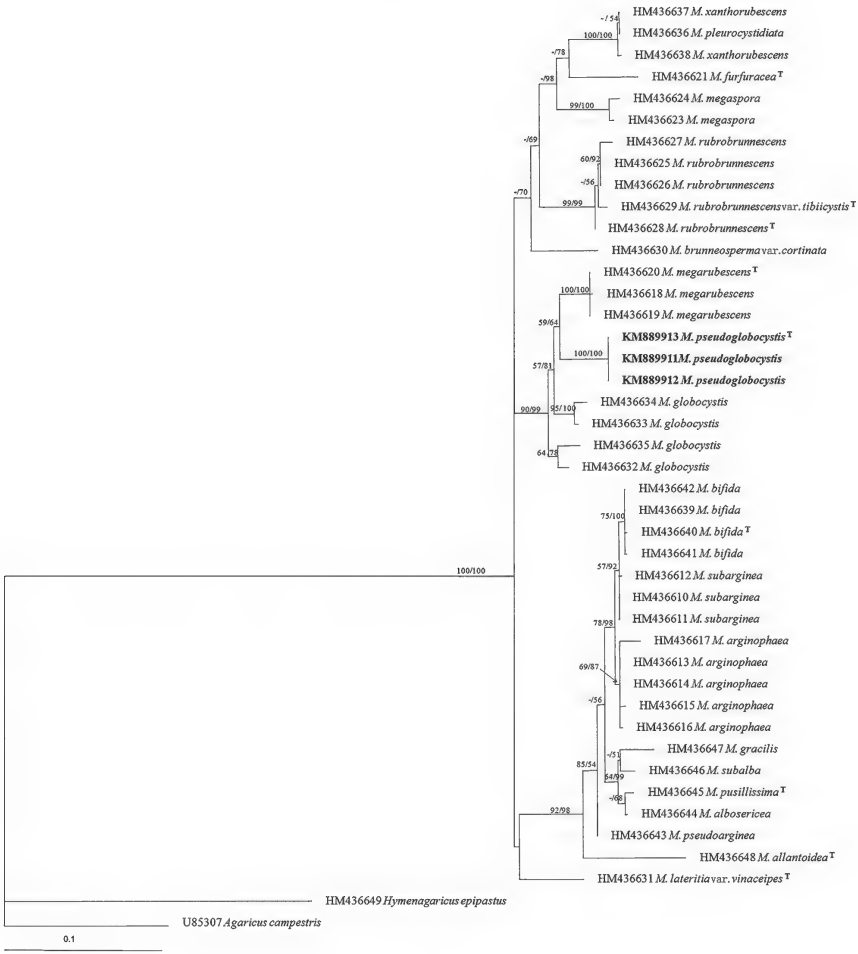


FIGURE 1 Phylogeny of *Micropsalliota* generated from Maximum Likelihood analysis of ITS sequences, rooted with *Agaricus campestris* and *Hymenagaricus epipastus*. Parsimony bootstrap support (BS) and Bayesian posterior probability (PP) values >50% are given at the internodes (BS/PP). "T" indicates a sequence from the type specimen. The new sequences produced from this research are in bold.

with a GTR+I+G model of nucleotide substitution, starting trees obtained via stepwise addition, random sequence addition and TBR branch swapping. Bayesian analysis was performed using Metropolis-coupled MCMC methods in MrBayes 3.1.2 with a GTR+I+G model and an inv-gamma distribution rate variation across sites. Chains were run for two parallel searches from random starting trees for 1 million generations

and trees were sampled every 100 generations. Those trees sampled prior to searches reaching a split deviation frequency value reaching 0.01 were discarded as burn-in (Huelsenbeck & Ronquist 2001; Huelsenbeck et al., 2001; Ronquist & Huelsenbeck 2003).

## Results

The ITS dataset included sequences from 43 specimens representing 22 taxa of *Micropsalliota*, with *Agaricus campestris* and *Hymenagaricus epipastus* as the outgroup (Zhao et al. 2010). The dataset had an aligned length of 733 characters in the dataset, of which 122 characters were excluded from all analyses, 389 characters are constant, 87 variable characters are parsimony-uninformative, and 135 characters are parsimony-informative. Maximum parsimony analysis recovered one equally parsimonious tree (L = 497 steps, CI = 0.626, RI = 0.806, RC = 0.504, HI = 0.374). Maximum likelihood analysis produced a single topology (–lnL = 3155.4316; Fig. 1). Bayesian analysis resulted in a single topology with an average standard deviation of split frequencies = 0.009789. The ML and Bayesian topologies are nearly identical, differing only in the position of *M. lateritia* var. *vinaceipes*. The ML tree is shown in Fig. 1.

According to the tree, *Micropsalliota* species form a monophyletic group with strong support (100BS/100PP values). The three samples cluster together with strong support (100BS/100PP values), and form a clade sister to *M. megarubescens* and *M. globocystis*.

## Taxonomy

***Micropsalliota pseudoglobocystis*** Li Wei & R.L. Zhao, **sp. nov.** Fig. 2

MycoBank MB 810860

Differs from *Micropsalliota globocystis* by its smaller basidiospores and its stipe covered by heavily fibrillose scales.

Type: China, Yunnan Province, Yingjiang County, Tongbiguan National Natural Reserve, 19 July 2013, collected by Qing-Hua Yu ZRL201332 (**Holotype** HMAS; **isotype**, SWFC; GenBank, KM889913).

Etymology: the epithet refers to the morphological and phylogenetic similarity to *Micropsalliota globocystis*.

Pileus 25–35 mm diam., broadly and obtusely conical when young, then expanding to 45–55 mm in diam., convex and subumbonate; margin recurved, crenate, splitting with age, rarely uplifted; surface dry, covered with dense fibrillose-scales, recurved, reddish-brown against the whitish background.

Figure 2 *Micropsalliota pseudoglobocystis* (holotype): A, B. Macrocharacters and discoloring on cutting and bruising; C, D. Cheilocystidia; E. Basidia; F. Basidiospores; G. Annulus hyphae; H. Pileipellis hyphae.

A
B
C
20 μm
D
20 μm
E
20 μm
F
20 μm
G
H

Context 2 mm thick, white. Lamellae free, crowded, with 2–4 series of lamellulae, 2–4 mm broad, at first white, then grayish white, finally dull brown, edges even entire. Stipe 42–126 × 5–8(–10) mm, cylindrical, sometimes with basal rhizomorphs, hollow, surface above annulus glabrous to fibrillose, below annulus floccose, scaly, white. Annulus pendent, single, membranous, superior, edge entire, persistent, white, 4–6 mm broad, upside smooth, lower side heavily fibrillose. Odor of seaweed. Staining bright yellow then reddish-brown when bruised or in exposure.

Macrochemical reaction: KOH reaction strongly reddish brown, dark brown in stipe.

Basidiospores 4.5–6 × 2.5–3.2 µm [$x = 5.1 \pm 0.3 \times 2.8 \pm 0.2$, $Q = 1.6–2.1$, $Q_m = 1.8 \pm 0.13$, n = 20], ellipsoid, amygdaliform, with apical thickening (endosporium), no germ pore, brown. Basidia 15–20 × 5–7 µm, clavate, hyaline, 4-spored. Cheilocystidia 40–50 × 10–13 µm, irregularly cylindrical to subclavate with a subcapitate to capitates apex, and often present a long, narrow and flexuous neck, smooth, hyaline. Pleurocystidia absent. Pileipellis a cutis composed of hyphae 7–18 µm diam., constricted at the septa, incrusted, contains brown membranous pigments. Annulus composed of hyphae of 5–10 µm diam. smooth, hyaline and branched.

Habit: gregarious on the bank of a forest trail.

Additional material examined: **China**, **Yunnan Province**, Yingjiang County, Tongbiguan National Natural Reserve, 19 July 2013, collected by Qing-Hua Yu ZRL2013323 (SWFC; GenBank KM889912); ZRL2013335 (SWFC; GenBank KM889911).

## Discussion

Other species of *Micropsalliota* with reddish-brown or purple brown scales on the pileus are *M. arginophaea* Heinem., *M. furfuracea* R.L. Zhao et al., *M. megaspora* R.L. Zhao et al., *M. pleurocystidiata* Heinem. & Little Flower, *M. xanthorubescens* Heinem., and *M. globocystis* Heinem. (Heinemann 1976, 1980; Zhao et al. 2010). All of these species differ from *M. pseudoglobocystis* morphologically, as well as phylogenetically: *M. arginophaea* does not discolor on bruising or cutting and has brown pileus scales; *M. furfuracea* has larger pileus scales; *M. megaspora* has larger basidiospores (6–7 × 3.5–4 µm); *M. pleurocystidiata* has pleurocystidia; *M. xanthorubescens* has medium-sized basidiomata (pileus 40–70 mm diam.); and *M. globocystis* has distinctly larger basidiospores (6–8 × 3.5–4.2 µm) and its stipe has a tomentose surface. Another phylogenetically closely related species is *M. megarubescens* R.L. Zhao et al., which differs by being slightly fibrillose on the disc of the pileus and glabrous elsewhere (Zhao et al. 2010).

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# Two new *Rosellinia* species from Southwest China

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Abstract— Two new species of *Rosellinia* from China are illustrated and described. *Rosellinia sigmoidea* differs from other species mainly in having a white entostroma and broadly rounded ascospores with sigmoid germ slits extending over half of the spore length. *Rosellinia camphorae* is unique because of its large ascus apical apparatus and ascospores with slimy sheaths. The herbarium and living culture are deposited in the Collection of Guizhou University (GZUC).

Key words— *Ascomycetes*, *Pezizomycotina*, taxonomy, *Xylariales*, *Xylariaceae*

## Introduction

*Rosellinia* De Not. (*Xylariaceae*), proposed in 1844 with *R. aquila* (Fr.) De Not. as its type species, is an important cosmopolitan genus. Stromata of *Rosellinia* are usually uniperitheciate and embedded in a persistent or fugacious subiculum. The ascus apical apparatus is well developed, especially in species with large ascospores. The asexual morph of *Rosellinia* species can be assigned to *Dematophora* R. Hartig, *Geniculosporium* Chesters & Greenh., or *Nodulisporium* Preuss (Greenhalgh & Chesters 1968, Rogers & Malmgren 1977, Petrini 1992, Stadler et al. 2013, Maharachchikumbura et al. 2015). Conidia are observed in the subiculum, on immature perithecia or in culture (Petrini & Petrini 2012). According to Petrini (2003) and Petrini & Petrini (2005), ascospore morphology is the most stable morphological character to delineate species. Currently, 142 species are accepted by Petrini (2013). *Rosellinia* species have been found on wood, dicotyledonous plants, and (occasionally) monocotyledonous hosts (Martin 1967; Pande & Rao 1995; Petrini 1992, 2003; Petrini et al. 1989; Roger 1953, Rogers 1979). Many *Rosellinia* species cause plant disease (Whalley 1996).

## Materials & methods

The fresh specimen was collected from Guizhou Province, China. Asci and ascospores were examined by light microscopy (BX41, Olympus). Material was mounted in water and Melzer's iodine reagent for examination. At least 20 propagules were measured to establish length and width ranges. Bubbles and spots have been removed from images.

## Taxonomy

***Rosellinia sigmoidea*** Q.R. Li, J.C. Kang, K.D. Hyde, **sp. nov.** PLATE 1

MYCOBANK MB 810825

Differs from all other *Rosellinia* species by its white entostroma and its broadly rounded ascospores with a sigmoid germ slit extending over half the spore length.

TYPE: China, Guizhou Prov., Guiyang, on dead wood, March 2014, Qirui Li (**Holotype**, GZUH0105).

ETYMOLOGY: The epithet refers to the sigmoid germ slit of ascospores.

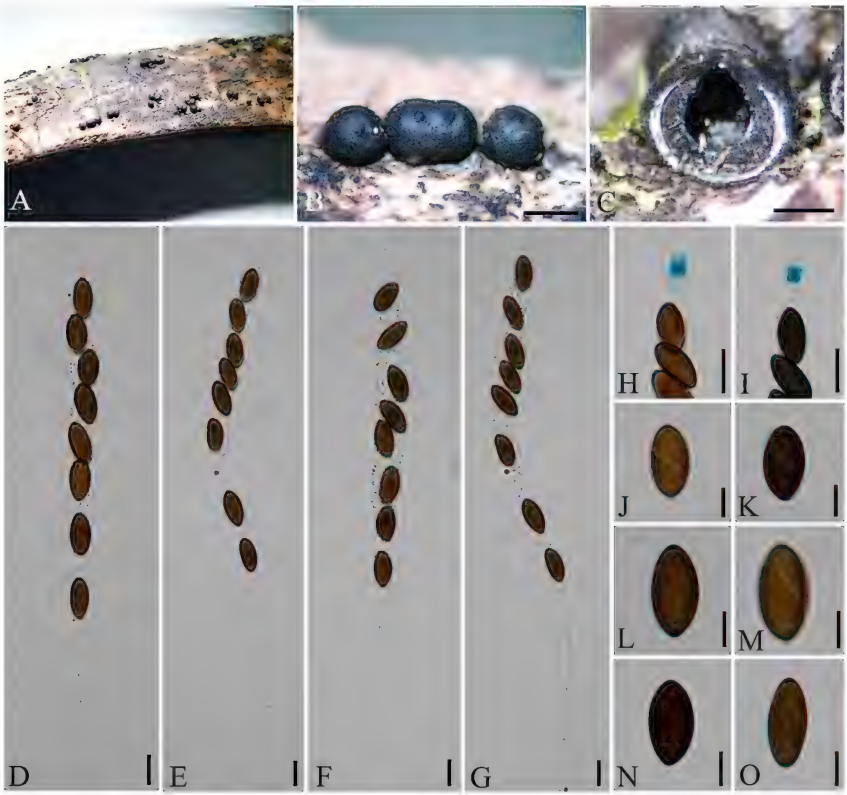


PLATE 1. *Rosellinia sigmoidea* (holotype, GZUH0105). A, B. Stromata on the host. C. Section of stroma. D–G. Asci. H, I. Urn-shaped, J+, apical apparatus. J–O. Ascospores. Scale bars: B = 500 μm; C = 200 μm; D–I = 10 μm; J–O = 5 μm.

Saprobic on woody material. Sexual morph: Subiculum evanescent, brown to black, gradually disappearing, absent in mature material. Stromata black, 0.4–0.8 mm diam., subglobose to globose, with a central ostiole, solitary or densely crowded in small groups. Ectostroma ≤90 µm thick, black. Entostroma white. Ascomata 350–600 µm high, 310–600 µm wide, easy detached. Paraphyses persistent at maturity, hypha-like, tapering slightly towards the rounded apex. Asci 116.5–224.5 × 10–15 µm (mean = 157.1 × 12.1 µm, n = 20), 8-spored, unitunicate, cylindrical, pedicellate, apically rounded, with an amyloid apical apparatus. Apical apparatus barrel-shaped, 3–5 µm high (mean = 4.3 µm, n = 20), upper width 3.5–5 µm (mean = 3.9 µm, n = 20), lower width 2.5–4 µm (mean = 3 µm, n = 20). Ascospores 12.5–15 × 6–7.5 µm (mean = 13.6 × 6.9 µm, n = 30), uniseriate, ellipsoidal, ends rounded, dark brown to black at maturity, unicellular, smooth-walled, with sigmoid germ slit about the half spore length, lacking sheath. Asexual morph: undetermined.

Comments—*Rosellinia lakshadweepensis* A. Pande & V.G. Rao differs from *R. sigmoidea* in its ascospores being surrounded by a slimy sheath; and *R. cibodasae* L.E. Petrini differs by its larger ascospores (21.9 × 6.8 µm) (Petrini & Petrini 2005, Petrini 2013).

***Rosellinia camphorae*** Q.R. Li, J.C. Kang, K.D. Hyde, **sp. nov.** Plate 2

MycoBank MB 810826

Differs from *Rosellinia procera* by its larger apical apparatus and its ascospores lacking caps at the ends and having a germ slit their entire length.

Type: China, Guizhou Prov., Guiyang, on deadwood of *Camphora* sp., March 2014, Qirui Li (**Holotype**, GZUH0113).

Etymology: The epithet refers to the host genus, *Camphora*.

Saprobic on woody material. Sexual morph: Subiculum evanescent, brown to black, gradually disappearing, absent in mature material. Stromata black, 0.8–1.2 mm high, 1–1.5 mm wide, subglobose to globose, with a central ostiole, solitary or densely crowded in small groups. Ectostroma up to 60 µm thick, black. Entostroma disappearing at maturity. Ascomata 500–1000 µm diam., 500–1000 µm high, black. Paraphyses persistent at maturity, hypha-like, tapering slightly toward the rounded apex. Asci 257–288 × 35–50 µm (265 × 41 µm, n = 20), 8-spored, unitunicate, clavate, short pedicellate, apically rounded, with a large amyloid apical apparatus. Apical apparatus barrel-shaped, 20–28.5 µm high, upper width 9–11 µm (9.5 µm, n = 20), lower width 14–16 µm (15.3 µm, n = 20). Ascospores 89–105 × 14.5–19 µm (99.5 × 17.2 µm, n = 20), bi-seriate, fusiform, ends rounded, dark brown to black at maturity, unicellular, smooth-walled, with a germ slit running the entire length of the spore, possessing a thin, slimy sheath. Asexual morph: undetermined.

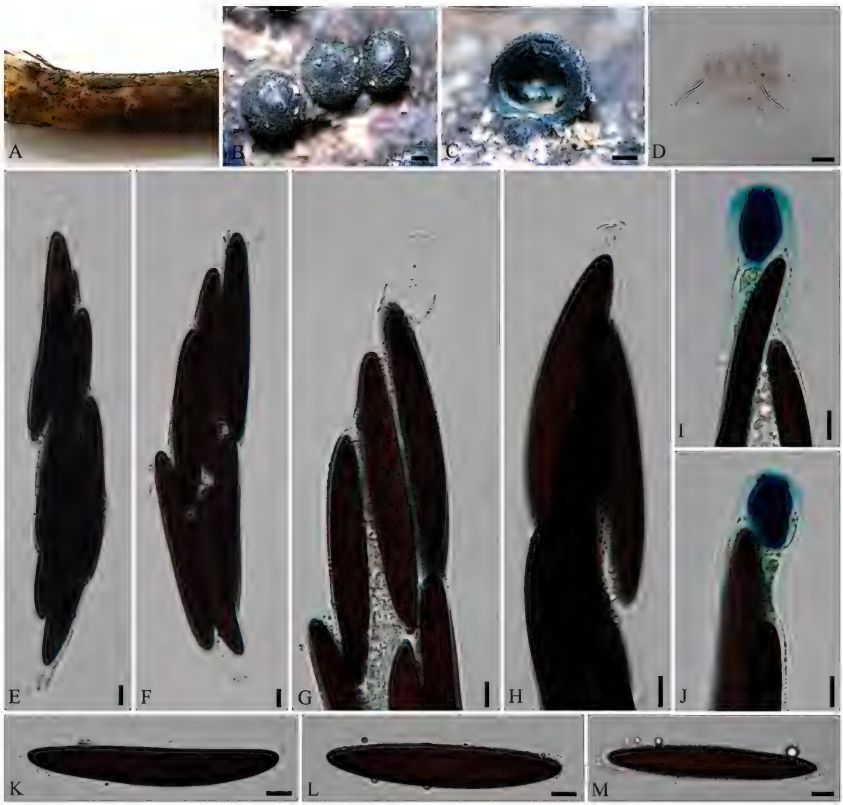


Plate 2. *Rosellinia camphorae* (holotype, GZUH0113). A, B. Stromata on the host. C. Section of stroma. D. Paraphyses. E–H. Asci. I, J. Urn-shaped, J+, apical apparatus. K–M. Ascospores. Scale bars: B, C = 500 μm; D = 50 μm; E–M = 10 μm.

Comments—*Rosellinia camphorae* is similar to *R. procera* Syd. & P. Syd., *R. megalosperma* Syd. & P. Syd., *R. formosana* Y.M. Ju & J.D. Rogers, *R. markhamiae* Sivan., and *R. saccasii* L.E. Petrini in ascospore size. However, *R. procera* differs by its smaller ascal apical apparatus (13–15 μm high, 8.5–10 μm broad) and its ascospores having caps at the ends, but lacking a germ slit (San Martín & Rogers 1995, Petrini & Petrini 2005, Petrini 2013); *R. megalosperma* differs by its ascospores having caps at the ends (Petrini & Petrini 2005); and *R. formosana*, *R. markhamiae* and *R. saccasii* differ by their smaller apical apparatus (Petrini 2013).

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# Some new records of *Uredinales* from Khyber Pakhtunkhwa, Pakistan

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Abstract — *Uromyces ferulae* and the telial stage of *Cerotelium fici* were collected from Khyber Pakhtunkhwa and are new records for Pakistan. *Puccinia exhausta* on *Clematis grata* and *P. ustalis* on *Ranunculus hirtellus* are reported as new host records for these rusts in Pakistan.

Key words —Oghi forest, *Pucciniales*, rust fungi

## Introduction

During the exploration of *Uredinales* of Khyber Pakhtunkhwa, Pakistan, rust-infected plants were collected from different localities and examined macro-microscopically. Among the specimens, *Heracleum cachemiricum* was found infected with *Uromyces ferulae,* which is a new record for Pakistan. The telial stage of *Cerotelium fici* on *Ficus carica* and *F. palmata* is an addition to the already reported stages of this rust from Pakistan. *Puccinia exhausta* on *Clematis grata* and *P. ustalis* on *Ranunculus hirtellus* are new host records for these rusts in Pakistan. This work brings the total of rust taxa recorded from Khyber Pakhtunkhwa to 174. Previously about 173 species of rust fungi have been reported from this area (Afshan & Khalid 2008, 2009; Afshan et al. 2008a,b,c,d, 2010; Ishaq et al. 2013).

## Materials & methods

Freehand sections & scrape mounts of infected plant materials were made in lactic acid. The plants were photographed and infected portions were observed under a stereomicroscope. Twenty spores representing each spore state were examined under a Nikon YS 100 microscope, and paraphyses and spore were measured using a Zeiss

eyepiece screw micrometer. Sections, paraphyses and spores were microphotographed by Digiporo-Labomed. Spores and paraphyses were drawn with the aid of a camera lucida (Ernst Leitz Wetzlar Germany). Specimens are conserved in the Herbarium, Hazara University, Dhodial, Pakistan (HUP).

## New records

***Uromyces ferulae*** Juel, Bull. Soc. mycol. France 17: 259. 1901. PLATE 1

SPERMOGONIA and AECIA were not found. UREDINIA and TELIA are mixed in the same sori, amphigenous and petiicolous, rounded, in dense clusters, especially on the leaflets, dark brown 0.09–0.26 × 0.25–0.41 mm. UREDINIOSPORES globoid or subgloboid, 22.4–24.1 × 26.9–27.9 µm (mean 23.4–27.6 µm), hyaline to golden brown, echinulate; germ pores 2–4, equatorial; pedicel hyaline, deciduous. TELIOSPORES globose to subglobose or ovoid to ellipsoid, 17.7–23.7 × 29.3–37.8 µm (mean 22.2–33.4 µm), apex rounded; wall 1.4–2.6 µm, light brown to chestnut brown, smooth; apex 2.8–5.2 µm thick, germ pore mostly at the apex, pedicel hyaline, deciduous.

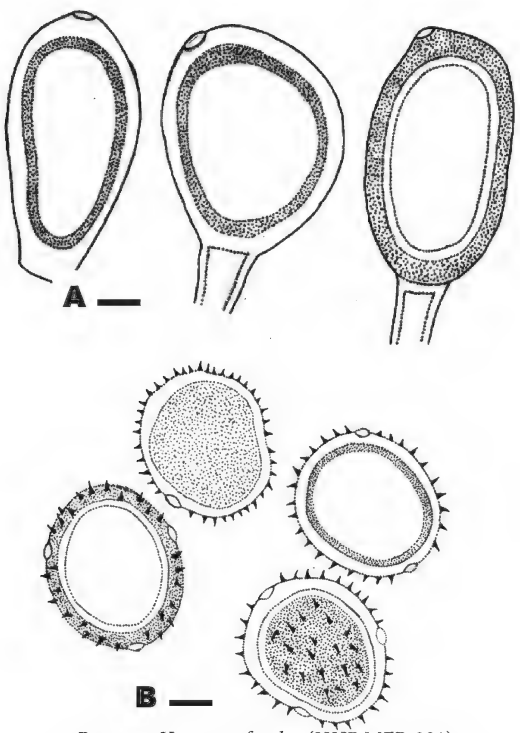


PLATE 1: *Uromyces ferulae* (HUP MFR-281):
A. Teliospores. B. Urediniospores. Scale bars = 10 µm.

Material examined: **PAKISTAN**, **Khyber Pakhtunkhwa**, District Mansehra, Oghi, Khabbal Paien, at 2046 m a.s.l., on *Heracleum cachemiricum* C.B. Clarke (*Umbelliferae*), stages II + III, May 2010, M. Fiaz #FR-208 (HUP MFR-281).

Comments: *Uromyces ferulae* has been reported on different *Ferula* species from North Africa, southern Europe, Australia, and Asia (Iran) (Saccardo & Saccardo 1905: 248; Mercé 1975; Denchev 1995). In Pakistan, no species of *Uromyces* has previously been recorded on *Umbelliferae*. This is the first report from Pakistan, and *Heracleum cachemiricum* represents a new host for *Uromyces ferulae*.

***Cerotelium fici*** (Castagne) Arthur, Bull. Torrey Bot. Club 44: 509. 1917. Plate 2

Spermogonia and aecia are unknown. Uredinia hypophyllous, scattered over the whole surface, minute, sometimes in large irregular groups, slightly

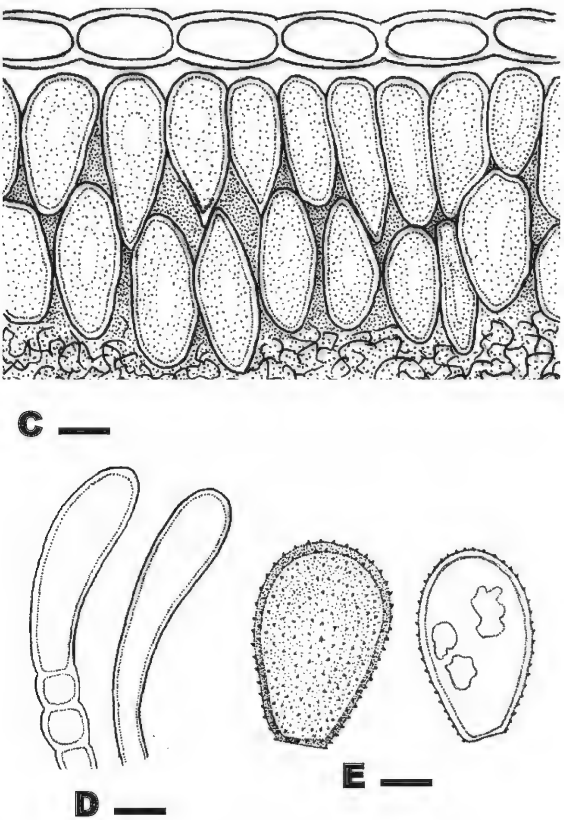


Plate 2: *Cerotelium fici* (HUF MFR-252): C. Subepidermal telium. D. Incurved paraphyses. E. Urediniospores. Scale bars: C = 9 cm; D = 8.5 µm; E = 6 µm.

erumpent, pulverulent, reddish brown, surrounded by peripheral, incurved and basally united paraphyses. Urediniospores subglobose or broadly ellipsoid to obovoid or ovate, densely echinulate, yellowish brown, 16–21.7 × 17–31.2 µm, wall 1–1.6 µm thick, germ pores scattered, obscure. Telia hypophyllous, subepidermal, scattered, minute, 190–270 µm in diam. Teliospores one-celled, cylindrical, broadly ellipsoid or oblong, smooth, 8.7–11.4 × 14.6–20.8 µm, catenulate, in two or three superimposed layers, walls uniformly thin, colorless.

Material examined: **PAKISTAN**, **Khyber Pakhtunkhwa**, District Mansehra, Bherkund, at 849 m a.s.l., on *Ficus carica* L. (*Moraceae*), stages II + III, Nov. 2010, M. Fiaz #FR-093 (HUP MFR-252); District Mansehra, Gulebagh, at 920 m a.s.l., on *Ficus palmata* Forssk., stage II, Oct. 2009, M. Fiaz #FR-089 (HUP MFR-253).

Comments: The telial stage of *Cerotelium fici* is a new record for Pakistan. The uredinial stage of *Cerotelium fici* has been reported on *Ficus carica*, *F. palmata*, and *F. religiosa* L. from Lahore, Change Manga, Sangla Hill, Tandojam, Malir (Karachi), and Rawalpindi (Ahmad 1956a,b, Hasnain et al. 1959, Khan & Kamal 1968, Ghaffar & Kafi 1968, Kaneko 1993).

***Puccinia exhausta*** Dietel, Bot. Jb. 28: 283. 1900. Plate 3

Spermogonia are usually epiphyllous, subcutaneous, chestnut-brown, spherical or ellipsoid, 74–117 × 79–126 µm. Aecia and uredinia not found. Telia amphigenous, small, rounded, scattered or in circular groups, dark brown to blackish, erumpent or covered by epidermis. Teliospores mostly ellipsoid, sometimes 1-celled and elongated, conical or rounded at the apex, base mostly roundish, apical wall may be thickened up to 3 µm, sometimes 2-celled, not thickened, slightly constricted or non-constricted at the septum, smooth, hyaline to yellowish and chestnut brown, 17–24 × 26–47 µm (mean = 21 × 39 µm), wall 1.4–2.5 µm, germ pore apical in upper cell, adjacent to the pedicel or basal in lower cell, distinct colorless papilla over the germ pore, sometimes up to 4 µm; pedicels hyaline, deciduous, rarely up to 80 µm long.

Material examined: **PAKISTAN**, **Khyber Pakhtunkhwa**, District Mansehra, Dhodial, at 978 m a.s.l., on *Clematis grata* Wall. (*Ranunculaceae*), stages 0 + III, Aug. 2010, M. Fiaz #FR-003. (HUP MFR-266).

Comments: *Puccinia exhausta* is cosmopolitan and reported on different *Clematis* species (Hiratsuka & Chen 1991, Hiratsuka et al. 1992, Kobayashi 2007). From Pakistan, it has previously been reported on *Clematis montana* Buch.-Ham. ex DC. from the Kawai and Malakandi forests (Kaghan valley) by Ono & Kakishima (1992) and Ono (1992). *Clematis grata* represents a new host record for *P. exhausta* in Pakistan.

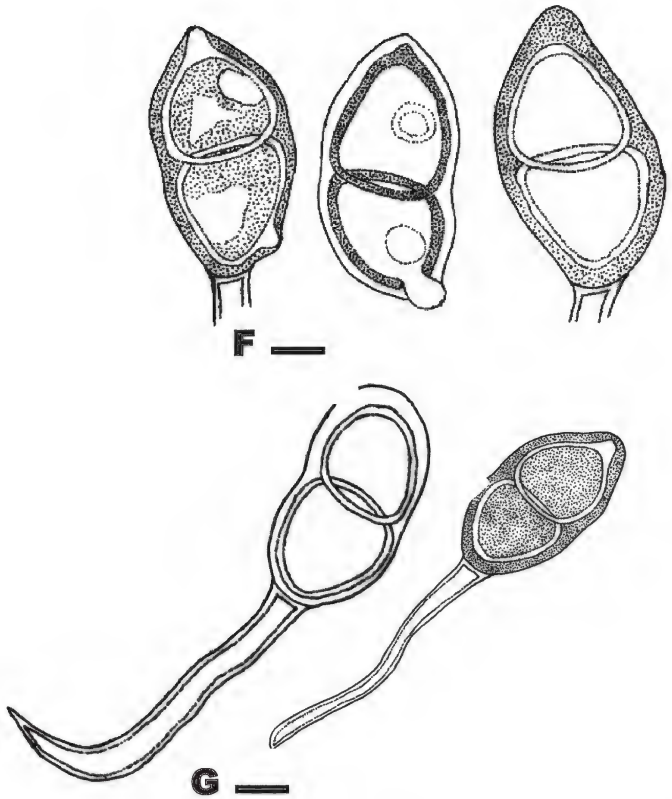


Plate 3: *Puccinia exhausta* (HUP MFR-266): Teliospores. Scale bar = 10 µm.

***Puccinia ustalis*** Berk. Hooker's J. Bot. Kew Gard. Misc. 6: 207. 1854. Plate 4

Spermogonia, aecia and uredinia are unknown. Telia usually hypophyllous as dark brown to blackish spots, scattered or aggregated in large groups, compact. Teliospores mostly 2-celled, occasionally 1- or 3-celled teliospores co-exist, ellipsoid, oblong to cylindrical or irregular, conical or rounded above and narrowed below, constricted at the septum, yellowish brown, pale brown basally; 2-celled spores 10–16 × 33–63 µm, smooth, 1–1.5 µm thick at side, apically 2–8.6 µm thick; germ pore one per cell, apical or sub apical in distal cell, in basal cell near the septum or obscure; 1-celled spores 8–11 × 17–33 µm, at side 1–1.5 µm, apices 2–5.4 µm thick; 3-celled spores 10–13 × 48–52 µm, 1–1.5 µm at sides and 2–6 µm at the apices. Pedicel pale yellow to hyaline, deciduous, 7–10 µm long.

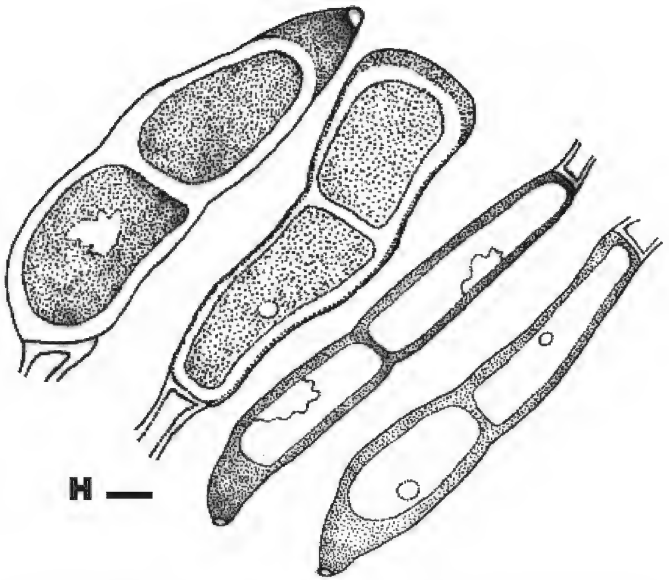


Plate 4: *Puccinia ustalis* (HUF MFR-272): Teliospores. Scale bar = 12 µm.

Material examined: **PAKISTAN**, **Khyber Pakhtunkhwa**, District Mansehra, Balakot, Nadibanglaw, at 2515 m a.s.l., on *Ranunculus hirtellus* Royle (*Ranunculaceae*), stage III, Jul. 2011, M. Fiaz #FR-005. (HUP MFR-272).

Comments: *Puccinia ustalis* is cosmopolitan and reported on different species of *Anemone*, *Clematis*, *Aquilegia*, *Pulsatilla*, *Ranunculus*, *Thalictrum*, and *Trautvetteria* (Hiratsuka et al. 1992). From Pakistan, it has been reported on *Anemone obtusiloba* D. Don from Changla Gali and Nathia Gali (Ahmad 1956a,b) and on *Ranunculus diffusus* DC. from Dunga Gali (Okane et al. 1992) and the Kaghan Valley (Ono 1992). *Ranunculus hirtellus* represents a new host record for *Puccinia ustalis* in Pakistan.

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# The genus *Allocetraria* (*Parmeliaceae*) in China

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Abstract—Ten species of *Allocetraria* are reported from China, including the new species *Allocetraria corrugata*, which is characterized by strongly rugose upper and lower lobe surfaces. A phylogenetic analysis based on nrDNA ITS sequences supports the independence of the new taxon. Diagnostic characters and distribution of the *Allocetraria* species occurring in China are given, and a key to the identification of the species is provided.

Key words— cetrarioid lichens, chemistry, comprehensive analysis, morphology, taxonomy

## Introduction

The lichenized genus *Allocetraria* Kurok. & M.J. Lai, which was described in 1991, comprised two species from other genera (the type, *A. stracheyi,* and *A. ambigua*) and one new species, *A. isidiigera.* The genus was originally characterized by dichotomously or subdichotomously branched lobes and foliose to suberect or erect thallus with sparse rhizines, angular to sublinear pseudocyphellae, a palisade plectenchymatous upper cortex, and the presence of usnic acid in the cortex (Kurokawa & Lai 1991). Randlane & Saag (1992) later transferred three additional taxa—*A. cucullata*, *A. nivalis*, and *A. potaninii*—based on morphological, anatomical, and chemical data. Subsequently, Kärnefelt et al. (1994) transferred *A. cucullata* and *A. nivalis* into a new genus *Flavocetraria*, distinguished from *Allocetraria* based on ascus structure and ascospore morphology.

Thell et al. (1995) described two additional new *Allocetraria* species and transferred three species from other genera—*A. flavonigrescens*, *A. sinensis*, *A. denticulata*, *A. globulans,* and *A. oakesiana*—and synonymized *A. potaninii* with *A. stracheyi.* At that time the genus was diagnosed as having a palisade plectenchymatous cortex, asci with a very broad axial body, globose or

subglobose ascospores, and filiform conidia (Thell et al. 1995). Later, Kärnefelt & Thell (1996) transferred two additional species to *Allocetraria*—*A. endochrysea* and *A. madreporiformis*.

Lai et al. (2007) established a new genus *Usnocetraria* and transferred numerous *Allocetraria* species into the new genus (all but two as invalidly published combinations). However, Thell et al. (2009) demonstrated that none of these species was closely related to the type species *Usnocetraria oakesiana* [≡ *Allocetraria oakesiana*]. Recently, Wang et al. (2014) described a new species *Allocetraria capitata* characterized by having capitate soralia on the top of lobes. During our taxonomic study of *Allocetraria*, we have identified an additional new species, which brings to ten the number of species accepted in the genus *Allocetraria*.

In its current circumscription *Allocetraria* is a well-supported monophyletic group within the cetrarioid clade (Saag et al. 2002, Thell et al. 2009, Nelsen et al. 2011), and China is the distribution center of the genus, with all ten species known to occur in China. An overview and a key to all ten *Allocetraria* species are provided below.

## Materials & methods

### Phenotypic study

A total of over 1000 specimens of *Allocetraria* from mainland China were examined. A dissecting microscope (Zeiss Stemi SV11) and compound microscope (Zeiss Axioskop 2 plus) were used to study the morphology and anatomy. All specimens are conserved in Herbarium Mycologium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS).

Color test reagents (10% aqueous KOH, saturated aqueous $Ca(OCl)_2$, and concentrated alcoholic *p*-phenylenediamine) and thin-layer chromatography (TLC, solvent system C) were used to detect lichen substances (Culberson & Kristinsson 1970, Culberson 1972).

### DNA extraction & PCR amplification

Twenty-seven freshly collected lichen specimens were chosen for DNA extraction (Table 1). The extraction procedure followed a modified CTAB method (Rogers & Bendich 1988). PCR amplifications were performed using a Biometra T-Gradient thermal cycler. The primer pairs ITS1 (White et al. 1990) and LR1 (Vilgalys & Hester 1990) were used to amplify the nrDNA ITS region. Reactions were carried out in 25 μl reaction volumes containing 0.5 μL total DNA, 1 μL each primer (10μM), 0.5 μL Taq polymerase (BIOTAQ_ DNA Polymerase, 3U/μL), 2.5 μL dNTP (10μM), 2.5 μL amplification buffer (10×), 2.0 μL $MgCl_2$, and 16 μL $ddH_2O$. Cycling parameters comprised an initial denaturation at 94°C for 5 min, 35 cycles of denaturation at 94°C for 50 s, annealing at 50–53°C for 50 s, extension at 72°C for 1 min, and a final extension at 72°C for 5 min.

TABLE 1. Specimens of *Allocetraria* spp. and outgroups used in the phylogenetic analysis

| SPECIES | VOUCHER | LOCALITY | GENBANK NO. |
|---|---|---|---|
| *A. ambigua* | Wang BM12059 | China | KF923756 |
| | Zhang Z11136 | China | KF923757 |
| | Zhang Z11139 | China | KF923758 |
| | Zhang Z11144 | China | KF923759 |
| | Zhang Z11145 | China | KF923762 |
| *A. corrugata* | Wang YK12033 | China | KF923760 |
| *A. endochrysea* | Wang BM12011 | China | KF923763 |
| | Wang YK12003 | China | KF923764 |
| | Wang YK12010 | China | KF923765 |
| *A. flavonigrescens* | Zhang Z11121 | China | KF923768 |
| | Wei & Chen QH12058 | China | KF923769 |
| | Wei & Chen QH12407 | China | KF923770 |
| | Wei & Chen QH12909 | China | KF923771 |
| | Wei & Chen QH12114 | China | KF923772 |
| | Wang BM12062 | China | KF923773 |
| **A. flavonigrescens* | Obermayer 08140 | China | AF404127 |
| **A. globulans* | Obermayer 08137 | China | AF404126 |
| *A. madreporiformis* | Wei 125691 | China | KF923774 |
| *A. sinensis* | Wang YK12008 | China | KF923775 |
| | Wang YK12025 | China | KF923776 |
| **A. sinensis* | Obermayer 08148 | China | AF404125 |
| *A. stracheyi* | Wang BM12029 | China | KF923777 |
| | Wang YK12005 | China | KF923778 |
| | Wang YK12009 | China | KF923779 |
| | Wang YK12016 | China | KF923780 |
| | Wang YK12030 | China | KF923781 |
| | Wang DQ12432 | China | KF923782 |
| **A. stracheyi* | Obermayer 143 | China | JX144031 |
| **A. ambigua* | Obermayer 08141 | China | AF404128 |
| **A. madreporiformis* | Obermayer 7746 | Austria | AF416460 |
| **Tuckermanopsis ciliaris* | | | HQ650615 |
| **Usnocetraria oakesiana* | | Germany | EU401757 |
| *Vulpicida juniperina* | Cao et al. HY11-243 | China | KF923786 |

* ITS sequences downloaded from GenBank. (All other sequences were obtained by the authors from specimens deposited in HMAS-L.)

### DNA sequencing & phylogenetic analysis

PCR products were sequenced using ABI 3700 Sequencer (Shanghai Boshang Corporation) and analyzed phylogenetically with software Mega5 (Tamura et al. 2011). The K2+G model was set according to the lowest BIC (Bayesian Information Criterion) scores. NrDNA ITS sequences of 27 specimens were generated, and 9 sequences were downloaded from GenBank (Table 1). Three genera included in the cetrarioid clade (*Tuckermanopsis ciliaris* (Ach.) Gyeln., *Usnocetraria oakesiana* (Tuck.) M.J. Lai & J.C. Wei, *Vulpicida juniperina* (L.) J.-E. Mattsson & M.J. Lai) were used as outgroup. The phylogenetic tree was inferred by maximum likelihood (ML), and the reliability of the inferred tree was tested by 1000 bootstrap replications. The intraspecific and interspecific genetic distances of the *Allocetraria* species were also calculated and compared.

## Results & discussion

### Phylogenetic analyses

Eight species of *Allocetraria*, including the new species, were included in our phylogenetic analysis. *Allocetraria capitata* and *A. isidiigera* are not included because we were unable to obtain fresh material. The ITS-based ML tree (Fig. 1) indicates that the 8 *Allocetraria* species form a well-supported (88% bootstrap value) monophyletic clade. Each species for which more than one specimen was included also formed a monophyletic clade. The backbone of the topology only received moderate support; additional loci will be necessary to address the phylogenetic relationships within the genus. However, the genetic distances (Table 2) based on nrDNA ITS sequences within *Allocetraria* provided more information. According to Del Prado et al. (2010), the distance based on the nrDNA ITS sequences of parmelioid lichens in *Parmeliaceae* (one of the largest lichenized families) has been shown to serve as a powerful tool for identifying species complexes. In our analysis of *Allocetraria*, the intraspecific distance range was 0–0.010 (most <0.006), while the interspecific distance range was 0.014–0.089. The closest distance of *A. corrugata* was to *A. flavonigrescens* (0.028), which was well separated from other species of *Allocetraria*.

### Morphology & chemistry

The *Allocetraria* thallus is characterized as foliose to subfruticose, dorsiventral or with radially symmetric branches, dichotomously or subdichotomously branched; upper surface yellow, greenish yellow, or brown; lobes flat, suberect to erect; pseudocyphellae angular or sublinear, marginal along the lower surface; sorediate or isidiate; lower surface wrinkled, yellowish, brown, or black; sparsely rhizinate; medulla white, yellowish, or orange yellow. Apothecia rare, terminal; 8 ascospores per asci, simple, near globose, 4–10 μm in diameter; pycnidia marginal, immersed or on emergent projections; pycnoconidia

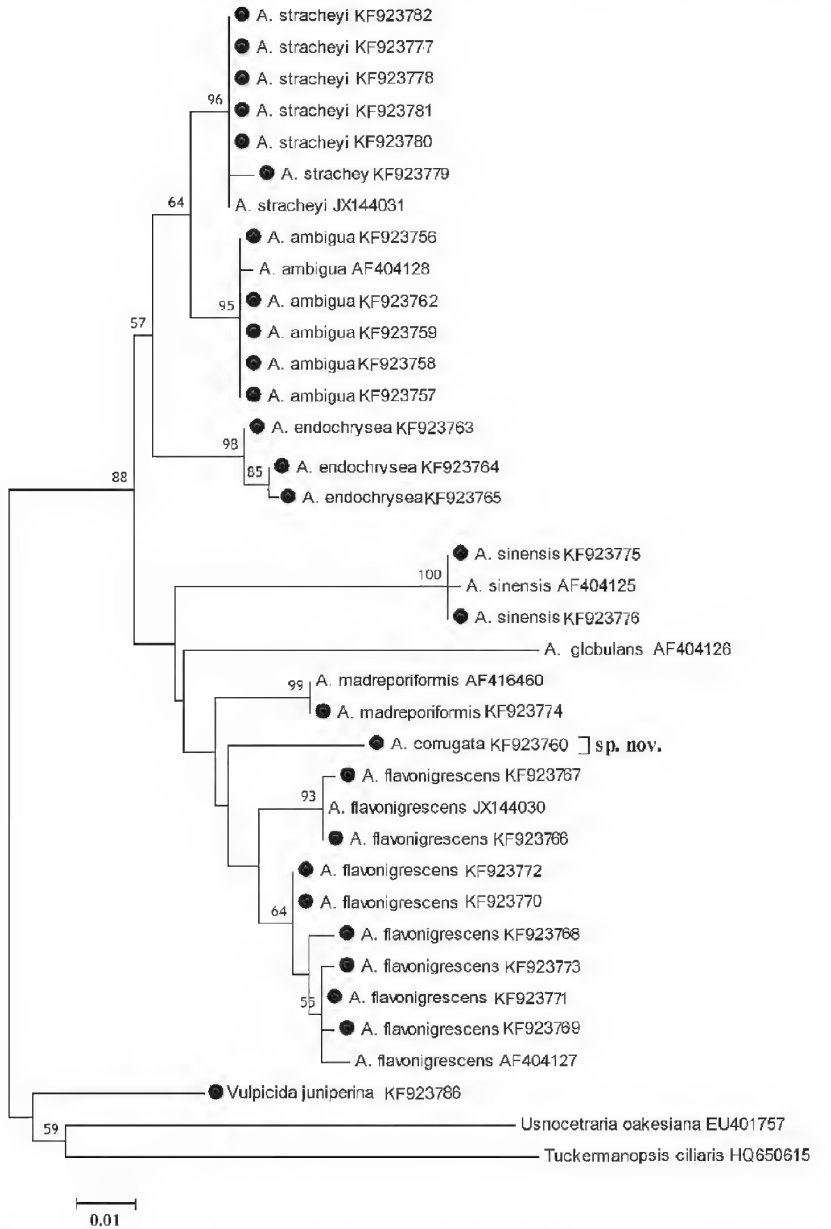


FIG. 1. The maximum likelihood tree based on nrDNA ITS region sequences of *Allocetraria* spp. The samples marked with '●' were examined by the authors. The numbers at each node represent bootstrap support values ≥50.

Table 2. Intraspecific and interspecific genetic distances range of the *Allocetraria* species

| Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 *A. ambigua* | 0–0.002 | | | | | | | |
| 2 *A. corrugata* | 0.045 | — | | | | | | |
| 3 *A. endochrysea* | 0.024–0.026 | 0.045–0.049 | 0.002–0.006 | | | | | |
| 4 *A. flavonigrescens* | 0.030–0.035 | 0.028–0.036 | 0.032–0.042 | 0.002–0.010 | | | | |
| 5 *A. globulans* | 0.057–0.059 | 0.075 | 0.069–0.073 | 0.057–0.073 | — | | | |
| 6 *A. madreporiformis* | 0.038–0.039 | 0.032 | 0.042–0.047 | 0.026–0.034 | 0.069 | 0 | | |
| 7 *A. sinensis* | 0.059–0.063 | 0.057–0.061 | 0.059–0.067 | 0.048–0.057 | 0.079–0.081 | 0.059–0.063 | 0–0.002 | |
| 8 *A. stracheyi* | 0.014–0.020 | 0.047–0.051 | 0.024–0.030 | 0.032–0.040 | 0.065 | 0.040–0.045 | 0.056–0.061 | 0–0.004 |

Notes: The numbers in the first row indicate the different species listed in column 1; — indicates no range because of single sample.

Table 3. Diagnostic characters of *Allocetraria* species

| Species | Soredia / isidia | Medulla | Conidial length | Chemistry | Substrate |
|---|---|---|---|---|---|
| *A. ambigua* | Absent | White | c. 15 µm | Usnic, lichesterinic, protolichesterinic, secalonic acids | Terricolous, corticolous |
| *A. capitata* | Capitate soralia | Yellowish to yellow | c. 15 µm | Usnic, fumarprotocetraric, protocetraric, secalonic acids | Terricolous |
| *A. corrugata* | Absent | White | <30 µm | Usnic, fumarprotocetraric, protocetraric acids | Saxicolous |
| *A. endochrysea* | Absent | Yellow | c. 15 µm | Usnic, lichesterinic, protolichesterinic acids, dufourin, endochrysin | Terricolous, corticolous |
| *A. flavonigrescens* | Absent | White | c. 15 µm | Usnic, fumarprotocetraric, protocetraric acids | Terricolous, corticolous |
| *A. globulans* | Absent | White | c. 15 µm | Usnic, lichesterinic, protolichesterinic, secalonic acids | Terricolous, corticolous |
| *A. isidiigera* | Isidiate | White | c. 15 µm | Usnic, fumarprotocetraric, protocetraric acids | Corticolous |
| *A. madreporiformis* | Absent | White | c. 15 µm | Usnic, lichesterinic acids | Terricolous |
| *A. sinensis* | Absent | White | c. 15 µm | Usnic, lichesterinic, protolichesterinic, secalonic acids | Terricolous, saxicolous |
| *A. stracheyi* | Absent | Yellowish to yellow | c. 15 µm | Usnic, lichesterinic, protolichesterinic, secalonic acids | Terricolous, corticolous, saxicolous |

filiform, 0.5–2×10–25(–30) µm. Both cortices are palisade plectenchymatous or paraplectenchymatous. Usnic acid is present in the cortex, while lichesterinic and protolichesterinic fatty acids are common in the medulla; secalonic acid occurs in several, and dufourin, endochrysin, fumarprotocetraric acid or protocetraric acid in some species.

The new species, *A. corrugata*, is diagnosed as having long conidia, numerous black spots on the margin and upper surface, and strongly rugose upper and lower lobe surfaces. It has the same secondary metabolites as *A. isidiigera* but differs in its flat lobes, an obviously rugose upper surface, and longer conidia (Table 3).

All *Allocetraria* species contain usnic acid, and most contain lichesterinic and protolichesterinic acids. *Allocetraria endochrysea* is characterized by containing dufourin and endochrysin in the medulla. The fumarprotocetraric acid chemosyndrome occurs in *A. corrugata*, *A. flavonigrescens* and *A. isidiigera*. Secalonic acid is found in *A. ambigua*, *A. capitata*, *A. globulans*, *A. sinensis* and *A. stracheyi*.

### Key to the ten species of *Allocetraria* in China

1. Thallus subfruticose to near columnar ..... 2
1. Thallus foliose ..... 3

2. Medulla white ..... *A. madreporiformis*
2. Medulla yellow ..... *A. endochrysea*

3. Isidia or soredia present ..... 4
3. Isidia and soredia absent ..... 5

4. Isidia present, medulla PD+ ..... *A. isidiigera*
4. Capitate soralia present, medulla PD– ..... *A. capitata*

5. Medulla PD+ ..... *A. flavonigrescens*
5. Medulla PD– ..... 6

6. Conidia up to 25–30 µm long ..... *A. corrugata*
6. Conidia up to 15 µm long ..... 7

7. Isidia-like lobules present ..... *A. stracheyi*
7. Isidia-like lobules absent ..... 8

8. Lower surface yellowish ..... *A. ambigua*
8. Lower surface brown to black ..... 9

9. Thallus erect ..... *A. globulans*
9. Thallus procumbent ..... *A. sinensis*

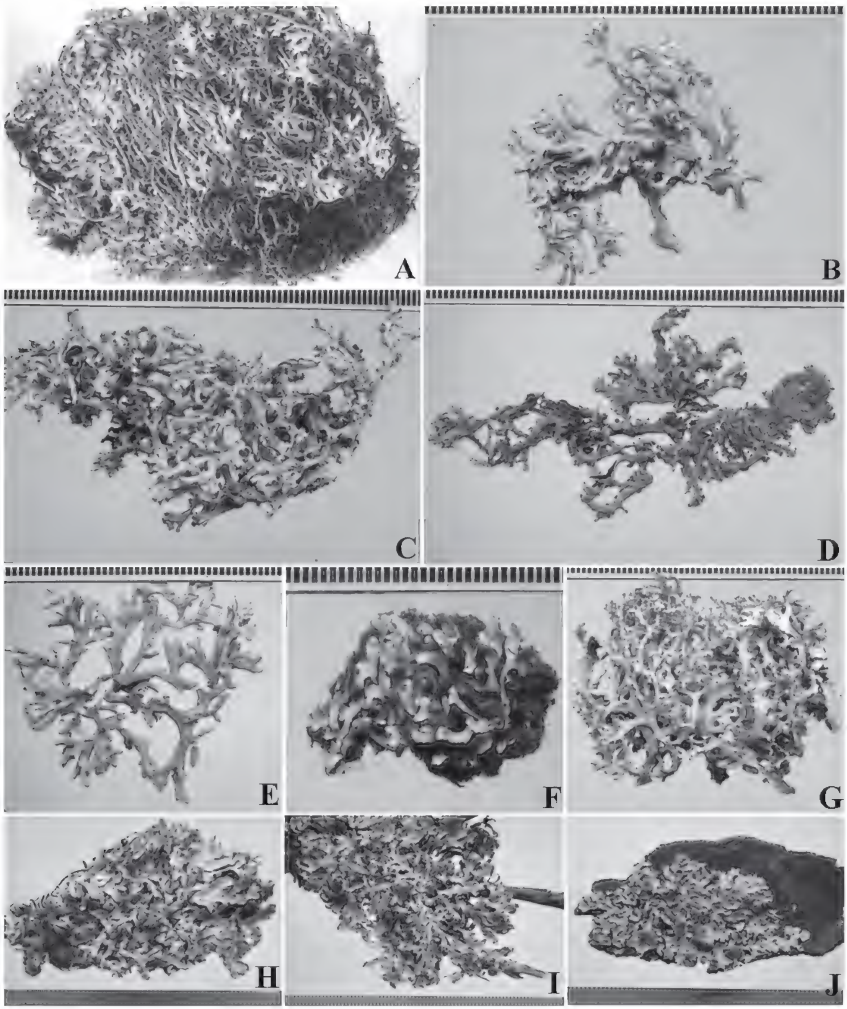


Plate 1. Habit of *Allocetraria* species. A. *A. ambigua* (HMAS-L 015005); B. *A. capitata* (isotype); C. *A. endochrysea* (HMAS-L 127390); D. *A. isidiigera* (holotype); E. *A. madreporiformis* (HMAS-L125691); F. *A. sinensis* (HMAS-L 127405); G. *A. stracheyi* (HMAS-L 015149); H. *A. flavonigrescens* (HMAS-L127395); I. *A. flavonigrescens* (HMAS-L 069642); J. *A. globulans* (HMAS-L015177). Scale in mm.

## Species

***Allocetraria ambigua*** (C. Bab.) Kurok. & M.J. Lai, Bull. Natl. Sci. Mus., Tokyo, B 17: 62, 1991. PLATE 1A

Characterized by thin flat channeled lobes and a yellowish lower surface, *A. ambigua* is similar to *A. stracheyi*, which is distinguished by thick convex lobes and isidia-like lobules.

CHEMISTRY—Usnic, lichesterinic, protolichesterinic, and secalonic acids.

SUBSTRATE—On soil or bark.

DISTRIBUTION—China (Gansu, Shaanxi, Sichuan, Tibet and Yunnan provinces), India, Nepal.

SPECIMENS EXAMINED: **CHINA**: **GANSU PROV.**: Mt. Minshan, alt. 4200 m, 23 August 1937, T.P. Wang 7582 (HMAS-L 014999); **SHAANXI PROV.**: Mt. Taibaishan, alt. 3200–3700 m, 12–13 July 1988, X.Q. Gao 3158 (HMAS-L 015003); X.Q. Gao 3185 (HMAS-L 015004); C.H. Ma 236 (HMAS-L 015000); C.H. Ma 238 (HMAS-L 015002); C.H. Ma 375 (HMAS-L 015005); alt. 3610 m, 23 July 2011, T. Zhang Z11136 (HMAS-L 127368); T. Zhang Z11139 (HMAS-L 127370); T. Zhang Z11144 (HMAS-L 127367); T. Zhang Z11145 (HMAS-L 127369); **SICHUAN PROV.**: Mt. Gonggashan, alt. 4200 m, 29 July 1982, X.Y. Wang et al. 9046 (HMAS-L 015009); **TIBET**: Nyalam County, 12 June 1966, J.C. Wei & J.B. Chen 1441 (HMAS-L 015137); **YUNNAN PROV.**: Deqen County, Mt. Baibaxueshan, alt. 4560 m, 16 September 2012, R.F. Wang BM12059 (HMAS-L 127372).

***Allocetraria capitata*** R.F. Wang, Li S. Wang & J.C. Wei, Mycosystema 33: 21, 2014. PLATE 1B

Characterized by having capitate soralia, *A. capitata* is similar to *A. isidiigera*, which is distinguished by its absence of soredia and presence of isidia.

CHEMISTRY—Usnic, fumarprotocetraric, protocetraric, and secalonic acids.

SUBSTRATE—On soil, often over moss.

DISTRIBUTION—China (Sichuan Province).

SPECIMENS EXAMINED: **CHINA**: **SICHUAN PROV.**: Dege Country, Manigangge villages, Mt Que'ershan, 31°55′N 98°56′E, alt. 4510 m, on moss, 30 August 2007, L.S. Wang et al. 07-28259 (KUN—holotype; HMAS-L—isotype).

***Allocetraria corrugata*** R.F. Wang, X.L. Wei & J.C. Wei, **sp. nov.** PLATE 2

FUNGAL NAME FN 570087

Differs from *Allocetraria isidiigera* by its longer conidia, numerous black spots on the margin and upper surface, and strongly rugose upper and lower lobe surfaces.

TYPE—China, Yunnan Prov., Deqin Co., Meli village, Meili snow mountain, on rock, 28°38′N, 98°37′E, alt. 4400 m, 10 Sep. 2012, R.F. Wang 12033 (**Holotype**, HMAS-L).

ETYMOLOGY—The epithet *corrugata* refers to the corrugated lobe surfaces.

Thallus foliose, adnate, dorsiventral; lobes narrow, 1–4 mm wide, slightly inflated, 200–450 μm thick, sublinear-elongate, sub-dichotomous to irregular branches, lobules irregularly branched; upper surface greenish yellow to

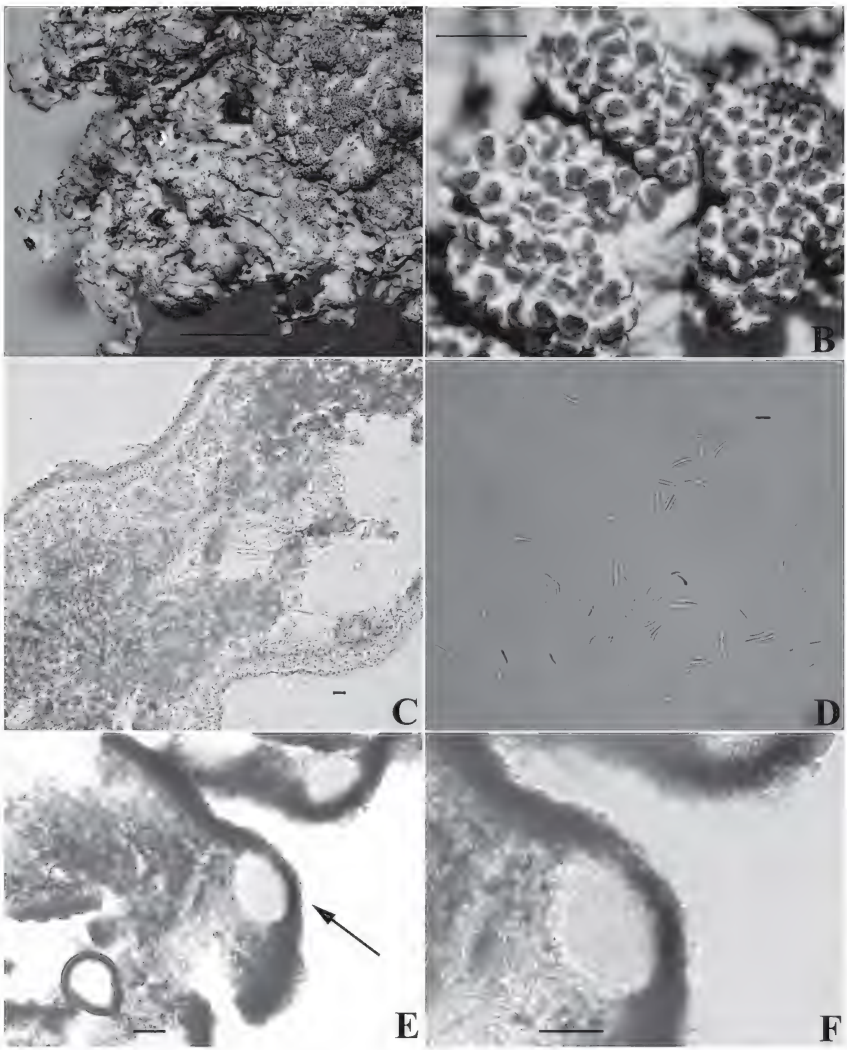


Plate 2. *Allocetraria corrugata* (holotype). A. Habit; B. The numerous black spots on the margin and upper surface; C. Longitudinal section of the thallus; D. Conidia; E. Longitudinal section of the thallus with black spots, hyphae inside and the arrow pointing at the location of one black spot; F. Magnification of the black spot pointed by the arrow in E. Scale bars: A = 1 cm; B = 1 mm; C, D = 20 μm; E, F = 5 μm.

green, strongly rugose, dark brown and whitish pruinose at the apices of lobes; spots dark brown to black, abundant, flush to emergent, scattered to crowded, mostly covered by white pruina; lower surface gray-white to pale brown, conspicuously rugose, rhizines marginal and laminal, concolorous with lower surface, sparse, unbranched, 1–4 mm long; pseudocyphellae rare, white, located on the ridges of the underside or on outgrowths; medulla white.

Upper cortex indistinct palisade plectenchymatous, 20–30 µm thick, composed of 3–6 layers; algal layer 25–50 µm; lower cortex paraplectenchymatous, 15–20 µm thick, composed of 3–4 layers; black spots at the upper surface not separated, composing of hyphae, the algal layer continuous. Apothecia not seen. Pycnidia frequent, both immersed and elevated on black projection, also at the top of isidia-like structures on the upper surface and margin, conidia colorless, filiform, one end slightly swollen, (12.5–)15–25(–30)×0.5–1.5 µm.

Chemistry—Cortex: K–, C–, KC+ yellow, PD–; medulla: K–, C–, KC–, PD+ yellow to red; containing usnic, fumarprotocetraric, and protocetraric acids (TLC).

Substrate—On rock, overgrowing mosses.

Distribution—Currently known only from Yunnan Province, China.

***Allocetraria endochrysea*** (Lynge) Kärnefelt & A. Thell, Nova Hedwigia 62: 507, 1996. Plate 1C

Characterized by a subfruticose thallus with a yellow medulla, *A. endochrysea* is similar to *A. madreporiformis*, which is readily distinguished by its less-branched lobes, white medulla, and absence of dufourin and endochrysin.

Chemistry—Usnic, lichesterinic, and protolichesterinic acids, dufourin, endochrysin.

Substrate—On soil, overgrowing mosses.

Distribution—China (Sichuan and Yunnan provinces).

Specimens examined: **China**: **Sichuan Prov.**: Mt. Gonggashan, alt. 4400 m, 21 October 1999, L.H. Chen 990051 (HMAS-L 127380); L.H. Chen 990087-1 (HMAS-L 127382); **Yunnan Prov.**: Deqen County, Mt. Baibaxueshan, alt. 4350–4440 m, 16 September 2012, R.F. Wang BM12011 (HMAS-L 127385); R.F. Wang BM12040 (HMAS-L 127388); 22 September 2012, Q.M. Zhou et al. DQ12432-1 (HMAS-L 127387); alt. 4800 m, 10 September 2012, R.F. Wang YK12001 (HMAS-L 127384); R.F. Wang YK12003 (HMAS-L 127391); R.F. Wang YK12010 (HMAS-L 127390); R.F. Wang YK12013 (HMAS-L 127389).

***Allocetraria flavonigrescens*** A. Thell & Randlane, Flechten Follmann Contr. Lich.: 359, 1995. Plate 1H, I

Characterized by long narrow channeled lobes, white medulla, and absence of pseudocyphellae, *A. flavonigrescens* is similar to *A. isidiigera*, which is distinguished by the presence of isidia.

Chemistry—Usnic, fumarprotocetraric, and protocetraric acids.

Substrate—On soil and corticolous on branches of *Rhododendron*.

Distribution—China (Qinghai, Shaanxi, Sichuan, Tibet, and Yunnan provinces), Nepal.

Specimens examined: **CHINA: Qinghai Prov.**: Maqin County, alt. 3970 m, 11 August 2012, X.L. Wei & K. Chen QH12058 (HMAS-L127395); X.L. Wei & K. Chen QH12407 (HMAS-L 128221); X.L. Wei & K. Chen QH12909 (HMAS-L 127447); Banma County, alt. 4299 m, 4 August 2012, X.L. Wei & K. Chen QH121141 (HMAS-L127394); **Shaanxi Prov.**: Mt. Taibaishan, alt. 3200 m, 12 July 1988, C.H. Ma 146 (HMAS-L 015094); alt. 3300 m, X.Q. Gao 3059 (HMAS-L 015091); X.Q. Gao 3051 (HMAS-L 015089); X.Q. Gao 3055 (HMAS-L 015092); alt. 3480 m, 23 July 2011, T. Zhang Z11121 (HMAS-L 128223); alt. 3360 m, 4 August 2005, J. Yang YJ218 (HMAS-L 069642); **Sichuan Prov.**: Mt. Zheduoshan, alt. 4200 m, 27 September 2007, L.S. Wang 07-28991 (KUN); **Tibet**: Mt. Dongdalashan, alt. 4950 m, HMAS-L 032363; **Yunnan Prov.**: Mt. Baibaxueshan, alt. 4560 m, R.F. Wang BM12062 (HMAS-L127396); R.F. Wang YK12036 (HMAS-L 126786); R.F. Wang YK12060 (HMAS-L 128222).

***Allocetraria globulans*** (Nyl.) A. Thell & Randlane, Flechten Follmann Contr. Lich.: 360, 1995. Plate 1J

A corticolous species characterized by long narrow channeled flat lobes with corrugated margins, *A. globulans* is similar to *A. stracheyi*, which is distinguished by convex lobes.

Chemistry— Usnic, lichesterinic, protolichesterinic, and secalonic acids.

Substrate—On bark.

Distribution—China (Yunnan Province), Nepal.

Specimens examined: **CHINA: Yunnan Prov.**: Mt. Yulongxueshan, alt. 3820 m, 6 August 1981, X.Y. Wang et al. 6854 (HMAS-L015180); alt. 3380 m, 6 August 1981, X.Y. Wang et al. 6550 (HMAS-L015179); alt. 3950 m, 6 August 1981, X.Y. Wang et al. 5110 (HMAS-L015178); Mt. Baimaxueshan, alt. 2700 m, 12 July 1981, X.Y. Wang et al. 7781 (HMAS-L015177).

***Allocetraria isidiigera*** Kurok. & M. J. Lai, Bull. Natl. Sci. Mus., Tokyo, B 17: 62, 1991. Plate 1D

Characterized by long narrow channeled lobes, a white medulla, and the absence of pseudocyphellae, *A. isidiigera* is similar to *A. flavonigrescens*, which is distinguished by the presence of isidia and slightly smaller conidia.

Chemistry— Usnic, fumarprotocetraric, and protocetraric acids.

Substrate—Corticolous on *Rhododendron* branches.

Distribution—China (Tibet), Nepal.

Specimens examined: **CHINA: Xizang (Tibet)**: Nyalam County, on *Rhododendron* stem, alt. 3910 m, J.C. Wei & J.B. Chen 1857 (Holotype, HMAS-L).

***Allocetraria madreporiformis*** (Ach.) Kärnefelt & A. Thell, Nova Hedwigia 62: 508, 1996. PLATE 1E

Characterized by a subfruticose thallus, erect lobes, and a white medulla, *A. madreporiformis* is similar to *A. endochrysea*, which is distinguished by a yellow medulla and the presence of dufourin and endochrysin.

CHEMISTRY—Usnic and lichesterinic acids.

SUBSTRATE—On soil.

DISTRIBUTION—China (Xinjiang Uygur Autonomous Region), Mongolia, Turkistan, West of North America, Central Europe.

SPECIMENS EXAMINED: **CHINA: XINJIANG UYGUR AUTONOMOUS REGION:** Mt. Tianshan, alt. 3200 m, 20 July 1978, X.Y. Wang 0950 (HMAS-L006687); 28 May 2011, J.C. Wei s.n. (HMAS-L125691); alt. 3000 m, 3 July 1997, X.Y. Wang 367 (HMAS-L006685).

***Allocetraria sinensis*** X.Q. Gao, Flechten Follmann Contr. Lich.: 365, 1995. PLATE 1F

Characterized by an erect thallus, long narrow channeled lobes, and a glossy lower surface, *A. sinensis* resembles *A. ambigua*, which can be distinguished by its yellowish lower surface.

CHEMISTRY—Usnic, lichesterinic, protolichesterinic, and secalonic acids.

SUBSTRATE—On soil.

DISTRIBUTION—China (Shaanxi, Sichuan, Yunnan, and Tibet), Nepal.

SPECIMENS EXAMINED: **CHINA: SHAANXI PROV.:** Mt. Taibaishan, alt. 3400 m, on ground, X.Q. Gao 3052 (Holotype, HMAS-L); alt. 3550 m, 13 July 1988, X.Q. Gao 3178 (HMAS-L 014992); **SICHUAN PROV.:** Mt. Gonggashan, alt. 2850 m, 24 June 1982, X.Y. Wang et al. 8260 (HMAS-014986); Mt. Balangshan, alt. 4300 m, 18 August 1982, X.Y. Wang et al. 9544 (HMAS-014990); X.Y. Wang et al. 9496 (HMAS-L 014988); **TIBET:** Zuogong County, alt. 4500 m, 8 October 1982, J.J. Su 5381 (HMAS-L014995); **YUNNAN PROV.:** Mt. Yulongxueshan, alt. 3970 m, 6 August 1981, X.Y. Wang et al. 7076 (HMAS-L 014996); Mt. Baimaxueshan, 16 September 2012, R.F. Wang YK12006 (HMAS-L 127405); R.F. Wang YK12008 (HMAS-L 127410); R.F. Wang YK12025 (HMAS-L 127406).

***Allocetraria stracheyi*** (C. Bab.) Kurok. & M.J. Lai, Bull. Natl. Sci. Mus., Tokyo, B 17: 62, 1991. PLATE 1G

Characterized by thick raised lobes and a yellowish lower surface, *A. stracheyi* is similar to *A. ambigua,* which differs in its thin flat lobes, and *A. capitata,* which differs in the presence of soredia.

Chemistry.—Usnic, lichesterinic, protolichesterinic, and secalonic acids.

SUBSTRATE—On soil and branches of shrubs.

DISTRIBUTION—China (Shaanxi, Sichuan, Xinjiang Uygur Autonomous Region, Yunnan, and Tibet), India, Nepal, North America.

SPECIMENS EXAMINED: **CHINA: SHAANXI PROV.:** Mt. Taibaishan, alt. 3600 m, 13 July 1988, X.Q. Gao 3151 (HMAS-L 015174); **SICHUAN PROV.:** Mt. Gonggashan, alt. 3700–3800 m,

27 June 1982, X.Y. Wang et al. 8354 (HMAS-L 015161); Mt. Balangshan, alt. 4300 m, 18 August 1982, X.Y. Wang et al. 9488 (HMAS-L 015168); **Tibet**: Zuogong County, alt. 4400 m, 8 October 1982, J.J. Su 5387 (HMAS-L015155); **Yunnan Prov.**: Mt. Baimangxueshan, alt. 4300 m, 29 August 1981, X.Y. Wang et al. 7546 (HMAS-L 029482); Mt. Daxueshan, alt. 4250 m, 8 September 1981, X.Y. Wang 7209 (HMAS-L015154); alt. 4330–4800 m, 8 August 1982, J.J. Su 5410 (HMAS-L 015149); Deqen County, 16 September 2012, R.F. Wang BM12029 (HMAS-L 127423); R.F. Wang YK12005 (HMAS-L 127428); R.F. Wang YK12009 (HMAS-L 127418); R.F. Wang YK12016 (HMAS-L 127427); R.F. Wang YK12030 (HMAS-L 127430); R.F. Wang DQ12432 (HMAS-L 127424); **Xinjiang Uygur Autonomous Region**: Mt. Tianshan, alt. 3200 m, 20 July 1978, X.Y. Wang 949 (HMAS-L 007697).

**Acknowledgements**

We are indebted to Prof. H. Thorsten Lumbsch and Prof. Jae Seoun Hur for giving valuable comments on the manuscript. This project was supported by the National Natural Science Foundation of China (31200018) and Main Direction Program of Knowledge Innovation of Chinese Academy of Sciences (KSCX2-EW-Z-9). We thank Ms. H. Deng for giving considerable assistance during the studies in HMAS-L.

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# Book reviews and notices

Else C. Vellinga (guest book review editor)

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Abstract—Books reviewed include: *Ascomycota*—Catalogue of discomycetes referred to the genera *Helotium* Pers. and *Hymenoscyphus* Gray (Lizoň & Kučera 2014); *Basidiomycota*—FunKey: an interactive guide to the macrofungi of Australia. Key to agarics (May & al. 2014); Checklist—Kommentierter Katalog der Flechtenbewohnenden Pilze Bayerns (von Brackel 2014).

Two different types of checklists are reviewed in this instalment of the book reviews. The first, which is of nomenclatorial interest, deals with the genera *Helotium* and *Hymenoscyphus;* the second checklist lists the fungi living on lichens in Bavaria. The third review looks at an interactive key for the genera of agarics in Australia. I foresee more of the latter type of publication in the future!

## *Ascomycota*

**Catalogue of Discomycetes referred to the genera *Helotium* Pers. and *Hymenoscyphus* Gray.** By P. Lizoň & V. Kučera. 2014. Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 9, SK-84523 Bratislava, Slovakia. <www.ibot.sav.sk> ISBN 978-80-971837-4-5. 144 pp. Price not known.

Since 1801 (or at least from 1849 onwards), more or less stalked, non-hairy and non-gelatinous inoperculate discomycetes were generally classified in the

[*] Book reviews or books for consideration for coverage in this column should be sent to the address above OR to the *Editor-in-Chief* at editor@mycotaxon.com or 6720 NW Skyline, Portland OR 97229 USA.

genus *Helotium* Pers., essentially paving the way for the genus to become an enormous heterogeneous collection of taxa. When in 1962 R.W.G. Dennis argued that this genus should be split up into a (small) genus *Helotium* and a (large) genus *Hymenoscyphus* Gray, M.A. Donk demonstrated that *Helotium* Pers. was a later homonym of the basidiomycete generic name *Helotium* Tode, thereby soon ending the currency of the discomycete genus *Helotium*. Since then, the genus *Hymenoscyphus* has increased considerably, by both new combinations and newly described taxa. It is beyond doubt that mycologists working on this group cannot avoid taxa once classified in *Helotium* and/or *Hymenoscyphus,* but they must make their way without world monographs of these species-rich genera.

Therefore Lizoň & Kučera have filled a gap by making a catalogue (checklist) of no less than 1183 specific and infraspecific epithets known to have at one time been attributed to *Helotium* and/or *Hymenoscyphus*. This number includes all validly published and a few unpublished or invalidly published names used in literature. Each entry comprises the *Helotium* and/or *Hymenoscyphus* name, the authority, the basionym, data about type substrate, country and specimen(s), the current name according to the authors or other authorities, and important taxonomic and/or nomenclatural remarks (e.g., about nomina nova or superfluous names). One entry does not necessarily present the complete synonymy of the taxon concerned. Where there is insufficient taxonomic information available or where there are different taxonomical opinions, a bold-faced current name is omitted. A short introductory chapter on the taxonomy and nomenclature of both genera and their common order (*Helotiales*) and family (*Helotiaceae*) precedes the actual catalogue. The book ends with an index of additional epithets mentioned within the entries.

It is evident that this publication has brought together a huge amount of relevant nomenclatural and taxonomical information about the taxa within the genera concerned. It also makes clear which taxa are, as yet, insufficiently known well enough for accurate classification.

Some critical remarks have certainly to be made here. In addition to many mistakes in spelling, typography (boldfaced instead of regular font), and grammar, the catalogue contains numerous inconsistencies. Abbreviations of author names, books, and periodicals are said to follow 'generally' (why not always?) the well-known standards, but the number of exceptions is fairly large: e.g., always 'Thind' instead of 'K.S. Thind' and sometimes 'Buchwald' for 'N.F. Buchw.', 'W. Phill.' for 'W. Phillips', 'Ell.' for 'Ellis', 'Sharma' or 'P.M. Sharma' for 'M.P. Sharma', 'B. Declercq' for 'Declerq', 'J. Hengstm.' for 'Hengstm.', 'P. Karsten' for 'P. Karst.', 'Monogr. Discomyc. Boh.' (Velenovský) for 'Monogr. Discomyc.

Bohem.', and 'Bidr. Känned. Finl. Nat. Folk' for 'Bidrag Kännedom Finlands Natur Folk' etc.

The way in which the authors use the equality sign (=), indicating heterotypic synonymy, and the triple bar (≡), indicating homotypic synonymy, is disputable. Combinations of *Helotium* or *Hymenoscyphus* and the epithet of an entry are not preceded by such a triple bar. If the basionym concerned or the current name, if homotypic, does not belong to one of these genera, it is preceded by a triple bar. However, sometimes the basionym is wrongly preceded by an equality sign (e.g., *Allophyllaria filicum*) or by no sign at all (e.g., *Phialea bicolor*). A nomen novum or recombination that is homotypic with the replaced name should be preceded by a triple bar, at any rate not by an equality sign as mostly is done in this book (e.g., under *destructor*, *robergei*, and *vernale*). It would have been more logical to precede not only the basionym but all its recombinations and nomina nova by a triple bar, as is usually done.

As far as possible, in each entry the current name is indicated and printed in bold (see above). Unfortunately this has been done rather inconsistently. For example, the entries *imberbe* and *pileatum* (P. Karst.) each contain two 'current' names. Under *cupularum, Hym. imberbis* is mentioned as the current name, but under *obliquum* its homotypic synonym, *Phaeohelotium imberbe*, is flagged as current. In several entries a current name is indicated which, according to the entry of the epithet concerned, is NOT the current name. For example, under *hymenulus* and *ostruthii, Hym. herbarum* is mentioned as current name, while under *herbarum* it is stated that *Calycina herbarum* is the current name. Similarly this applies to *Hym. epiphyllus* in the entries *gyalectoides* and *lunatum* resp. *epiphyllum*. Under *phiala,* an invalidly published name is even marked as the 'current' name.

The authors appear to have paid attention to the inclusion of orthographic errors that, as usual, are placed between single quotation marks and brackets behind the corrected form. However, many orthographic errors remain, even in the labels of the entries, e.g., *aspidiicolum*, *caulicolum,* and *pinicolum*.

The conclusion may be that this catalogue is certainly an asset for all mycologists who are engaged with helotioid discomycetes. Unfortunately the many inaccuracies, which could have been prevented by a more thorough final editing, detract from the quality. Therefore this catalogue is not the dependable standard work for both genera that it might have been.

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*Basidiomycota*

**FunKey: an Interactive Guide to the Macrofungi of Australia. Key to Agarics.** version 1. By T. W. May, K. Thiele, C. W. Dunk, S. H. Lewis. 2014. Identic, Brisbane and ABRS, Canberra. <http://shop.lucidcentral.org/>. ISBN 978-0-642-56877-9. 1200+ images (numerous in colour) for 159 taxa and 383 character states. Price: $50.73 (USB 2.0 Key).

> FunKey is also available as an "app" for mobile devices using Apple or Android systems. The app provides the interactive key and fact sheets for genera and characters. However, the app does not include the extensive introductory material on genera and characters or the glossary that is present on the USB version. In the app, the best function is available, but not other Lucid key functions such as subsets or ranked sort. Purchase direct from either the iTunes store:
> https://itunes.apple.com/WebObjects/MZStore.woa/wa/viewSoftware?id=958085767&mt=8
> or Google Play:
> https://play.google.com/store/apps/details?id=com.lucidcentral.mobile.funkey&hl=en

According to its introduction, "FunKey: Key to Agarics" is an interactive key and information system for the agaric genera occurring in Australia.

FunKey is available on a USB key or, in a slimmed down version, as an app for mobile devices. I reviewed the USB version. The system requirements for this program are an Internet browser with installed Java plug-ins. Once installed, it feels like working on-line, even though all data are present on the USB key.

The main part is formed by the interactive keys where you can start with whatever character you wish; as you select a character from a list of characters and character states, groups of taxa or genera are left in the in-group while others move to the discarded group. For instance, if you choose white spores, all species with coloured spores are immediately eliminated from the list of possible candidates. The final selections can be further examined, as the fact-sheets for every species/species group provide extensive information.

The keys work well; I tested them with *Macrolepiota clelandii* and an *Agaricus*. However, users should be well aware that in many cases the keys do not lead you to a species but to a genus, species group, or section of a genus. A second caveat is that for many Australian species, names are not yet available, so that can be frustrating as well.

What makes this so valuable is all the background information. There is a fact sheet for each genus or group with notes on characteristics, distribution in Australia, photos, a list of references; there is also extensive discussion and argument for generic placements, a glossary for all the terms used in the keys and descriptions, and a compiled list with all references.

These resources make this a very useful work for people in other countries. FunKey is also an example how to make data on fungi more easily accessible than is possible in traditional publishing formats such as dichotomous keys or written descriptions without keys. Of course, as version 1 is only the beginning, I am looking forward to expanded updates with keys to all the named species.

## Checklist

**Kommentierter Katalog der Flechtenbewohnenden Pilze Bayerns**. By W. von Brackel, 2014. Bibliotheca Lichenologica Volume 109. J. Cramer, Johannesstr. 3A, 70176 Stuttgart, Germany, mail@schweizerbart.de, <www.borntraeger-cramer.de> ISBN 1436-1698. 476 pages, 13 illustrations. Price 119.00 €

Since 2004, von Brackel has focused on the lichenicolous fungi of Bavaria, of which he has documented and identified 1900 collections. The present work is the result of that very labour intensive research, conducted mostly in the author's evenings and weekends.

In all, von Brackel has identified (and here reports on) 403 species in 141 genera, including 372 obligate lichenicolous species and 31 others that are partly lichenized, facultatively lichenicolous, or have a taxonomy and ecology that are not well known. Five species new for science are introduced, and one new combination is proposed.

The book starts with a short introduction outlining the history of the discovery and cataloguing of the lichenicolous fungi in Bavaria—a history that goes back to the early 1800s. The author emphasizes that wherever there are lichens, there are fungi growing on them. However, it is important to remember that the ecological requirements of host and fungal symbiont are not always the same, and that their sensitivity to air pollution might differ.

The methods section explains how the data were collected in the field, where the collections are conserved, and how the book is organized.

The most important part follows: an alphabetical enumeration of genera and species that is over 400 pages long. For each genus a short introduction on taxonomic position, morphological characters, and ecology is given. The species are treated more in depth: name, synonyms, hosts, literature, comments, distribution (based on literature), distribution in Germany, finds in Bavaria (literature), and the author's own observations and collections are enumerated.

Acknowledgements followed by a list of references (almost 60 pages long) complete this work.

The 'catalogue' is a fascinating and important contribution to our knowledge of an often-neglected group of fungi. With this overview for Bavaria, comparisons with the checklist of lichenicolous fungi in Great Britain and Ireland (Hawksworth 2003) can be made, leading to better insight in distribution patterns and ecology.

I am not a specialist in this group, so I cannot comment on the nomenclature, and nomenclatorial issues always arise while compiling a book like this. While browsing through its pages, however, I noticed only one typographical error.

The author can be congratulated on such an important and thorough work. I hope that this printed book will also be available in an electronic version, which would make it so much easier to update and to consult than the hard-copy edition.

Hawksworth DL, 2003. The lichenicolous fungi of Great Britain and Ireland: an overview and annotated checklist. The Lichenologist 35: 191–232.

## Book Announcements

**Hypocrealean lineages of industrial and phytopathological importance**. By L. Lombard, J.Z. Groenewald & P.W. Crous (Eds). 2015. Studies in Mycology 80. <www.cbs.knaw.nl>. ISSN 0166-0616. 245 pp., full colour. **Price:** € 70.00(free download).

**Philatelic Mycology: Families of fungi.** By W.F.O. Marasas, H.M. Marasas, M.J. Wingfield & P.W. Crous. 2014. CBS Biodiversity Series 14. <www.cbs.knaw.nl>. ISBN 978-90-70351-99-1. 107 pp., full colour. Price: € 40.00.

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# Nomenclatural novelties and typifications proposed in Mycotaxon 130(2)

*Allocetraria corrugata* R.F. Wang, X.L. Wei & J.C. Wei, p. 585
*Anaexserticlava* T.S. Santa Izabel, R.F. Castañeda & Gusmão, p. 446
*Anaexserticlava caatingae* T.S. Santa Izabel, R.F. Castañeda & Gusmão, p. 446
*Aspicilia volcanica* Ismayil, A. Abbas & S. Y. Guo, p. 545
*Brachycephala* J.S. Monteiro, Gusmão & R.F. Castañeda, p. 490
*Brachycephala exotica* J.S. Monteiro, Gusmão & R.F. Castañeda, p. 490
*Chaetochalara mutabilis* C.R. Silva, S.S. Silva, Gusmão & R.F. Castañeda, p. 506
*Corneromyces murrillii* (Burt) Nakasone, p. 374
*Cryptocoryneum parvulum* S.S. Silva, Gusmão & R.F. Castañeda, p. 466
*Digicatenosporium* S.M. Leão, Gusmão & R.F. Castaneda, p. 480
*Digicatenosporium polyramosum* S.M. Leão, Gusmão & R.F. Castaneda, p. 480
*Diplococcium heteroseptatum* D.A.C. Almeida, T.S. Santa Izabel, R.F. Castañeda & Gusmão, p. 497
*Distophragmia* R.F. Castañeda, S.M. Leão & Gusmão, p. 499
*Distophragmia rigidiuscula* (R.F. Castañeda) R.F. Castañeda, S.M. Leão & Gusmão, p. 500
*Duportella lassa* Spirin & Kout, p. 484
*Endophragmiella selenosporellaria* Y.R. Ma & X.G. Zhang, p. 452
*Graphilbum tsugae* J. Reid & Georg Hausner, p. 409
*Graphis hongkongensis* Wei Guo & J.S. Hur, p. 431
*Leptogium taibaiense* H.J. Liu & M.Q. Xi, p. 472
*Leptogium wangii* H.J. Liu & J.S. Hu, p. 473
*Leucoagaricus lahorensis* Qasim, Amir & Nawaz, p. 534
*Matsushimiella paraensis* J.S. Monteiro, R.F. Castañeda & Gusmão, p. 312
*Melanoderma disciforme* H.S. Yuan, p. 424
*Micropsalliota pseudoglobocystis* Li Wei & R.L. Zhao, p. 558
*Neosporidesmium diaoluoshanense* Xiang Y. Li & X.G. Zhang, p. 308

*Phaeoschizotrichum* C.R. Silva, Gusmão & R.F. Castañeda, p. 438
*Phaeoschizotrichum ramosum* C.R. Silva, Gusmão & R.F. Castañeda, p. 438
*Polyporus epitheloides* Nakasone, p. 388
≡ *Peziza flava* Sw. : Fr., 1788
non *Polyporus flavus* Jungh., 1838
*Polyporus polyacanthophorus* Nakasone, p. 383
≡ *Hydnum brunneoleucum* Berk. & M.A. Curtis, 1857,
non *Polyporus brunneoleucus* Berk., 1846
*Pseudolagarobasidium conspicuum* (Pouzar) Nakasone, p. 378
*Pyriculariopsis bicolorata* C.R. Silva, Gusmão & R.F. Castañeda, p. 441
*Rosellinia camphorae* Q.R. Li, J.C, Kang & K.D. Hyde, p. 565
*Rosellinia sigmoidea* Q.R. Li, J.C, Kang & K.D. Hyde, p. 564
*Spadicoides sylvatica* Heredia, R.F. Castañeda & R.M. Arias, p. 512
*Sporidesmiella mammillata* Heredia, R.F. Castañeda & R.M. Arias, p. 514
*Vararia amurensis* (Parmasto) Nakasone, p. 377

bad taxonomy

can KILL